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ACCIDENTS IN HIGH TENSION WORKS.

FATAL accidents in electric light works have been lamentably frequent of late. Within the past 12 or 15 months there have been at least four, that have occurred in English works. It ought to be clearly recognised that such accidents may have a prejudicial effect on electric lighting, and may certainly tend to raise a want of confidence in high tension systems. With the most perfect apparatus there is always the possibility of a mistake being made which may lead to fatal results, but the question arises as to whether sufficient precautions are adopted to prevent mishaps. The very nature of high tension work necessitates more than ordinary measures being taken to guard against fatalities, but we are very much afraid that in many cases no greater caution is shown in high tension stations than in low pressure works.

It would be grossly unfair to say that the engineers in charge of the high tension works that exist in this country have not a due regard for the lives of their assistants and workmen, but the matter may be, and very often is, out of their control. They are not usually responsible for the design of the works, and occasionally, we fear, they have not sufficient interest or courage to suggest remedial measures. It must be understood that we are speaking of the matter in a general sense. We do not for a moment wish to make any reflections on those works where fatal accidents have occurred; we are not even going into the question of how the accidents happened there. Under the best-regulated conditions, as we have already said, there may be mishaps, but there is no real reason why high tension work should not be safer than it is, and it is certainly incumbent upon the designers that everything in their power is done to prevent possible injury or loss of life.

The weaknesses of a high tension system, providing there are any, are usually at the back of the station switchboard, or at the distributing station, therefore it is at these points that ingenuity should be displayed to make apparatus workably safe. It is regrettable to have to say so, but there are distributing stations and switchboards existing that are little better than death traps. That fortunately does not represent the general state of things, but while some exist we may expect occasional fatalities. To our own knowledge, there are switchboards of important electrical works where the smallest error in the manipulation of the gear might result in a fatality. That is obviously a state of things that ought not to exist. In the design of high pressure apparatus, one has to do more than provide against ordinary contingencies; extraordinary circumstances must be allowed for. In other words, the manipulators of switch gear, and those that go down into sub-stations, must be so protected that no error of theirs shall bring on them the awful penalty of death.

It is unfortunate, but we are afraid true, that many station engineers are apparently quite indifferent to the danger of employing badly-designed apparatus with which to manipulate the current. We are not desirous of blaming them unnecessarily. They have been appointed to run plant which they know full well possesses many unsafe features, but for the sake of a life of peace they make no complaint. Many, on the other hand, have had the boldness to go to their committees and tell them the unpleasant fact that switch gear which had only recently been installed was defective and dangerous, and that for the sake of giving a good supply and having freedom from danger the committee must authorise the spending of more money.

More of that boldness will need to be exhibited before we can claim that high tension work is practically safe. The interests of the great electrical industry, but above all those of common humanity demand a higher degree of safety, and it is our sincere hope that the designers of high tension apparatus and the engineers of central stations will in the future regard these more than they have done in the past.

RECTIFIERS AND RECTIFIED ARC LIGHTING.

For many years electrical engineers have talked about motor commutators and devices for commutating alternating into continuous or direct currents. One suggestion appeared in the correspondence columns of this journal some eight or nine years ago, when Mr. St. George Lane Fox submitted a sketch of an apparatus for converting alternating into continuous currents to us, believing that "some such contrivance would be useful in conjunction with the distribution of energy by means of transformers." Another worker in the same field, and one who has achieved practical results, is Dr. Charles Pollak, whose method of transforming alternating into continuous currents was fully described in a paper read before the International Electrical Congress at Chicago in 1893, and a view of the apparatus employed by this inventor will be found on page 439 of the *Proceedings* of the Congress. Some of our readers may remember that Dr. Pollak exhibited his rectifier at work during the Friday evening discourse delivered by Professor S. P. Thompson, at the Royal Institution, on Alternating Currents, a year or two ago.

Mr. Ferranti took up the problem of rectification many years ago, and the results of his extended series of experiments are shown in the rectifiers that are employed in practical work at Portsmouth, Cardiff, Southport, Tunbridge Wells, Islington, and Edinburgh. Although it has been suggested that rectifiers offer a promising field in the adaptation of storage batteries to alternating current supply systems, we are not aware that any serious attempt has been made to use them in this country for the purpose, although Dr. Pollak has so used his type in the conversion of alternating to direct currents for the forming of battery plates. Another idea mooted is that electric traction systems could be supplied with rectified currents, and the very desirable feature of a day load might to some extent be attained by municipal supply stations. Although it is said that the plant is ready in conception, and only waiting for the demand for such a use to bring it within the sphere of practice, nothing has yet been done to support such assertions.

Mr. Hesketh, as Borough Electrical Engineer of Blackpool, has had practical experience with a Ferranti rectifier in regular work. The results seemed so satisfactory to him that a short time ago he published an article in our American contemporary, *Electrical Engineering*, in which he particularised the advantages of running public arc lamps by rectified alternating currents. After mentioning the fact that 100-light arc machines are common in the United States, but that 50-lighters were considered large in this country, and stating that the efficiency of constant current machines is notorously low (the reason for this, we may add, has frequently been given by Mr. Swinburne in papers read by him before the Institution of Electrical Engineers and other societies), Mr. Hesketh goes on to say that it is borne very strongly upon him that the Ferranti rectifier is a step in the right direction. The next paragraph is too good to be paraphrased, and we will give it intact. "To those engineers who have not practically worked this apparatus it would at first appear that there *must* be some incidental trouble either with the regulation, the motor, or some such part of the arrangement; but, in practice, these fancied troubles do not appear. From 'start' to 'shut down' the rectifier gives no more trouble than an ordinary circuit for incandescent lighting, and in its present advantages we see the promises for the future, or, at least, indications of the direction in which progress is to be made." The efficiency (presumably at full load) of a rectifier is given as 86 per cent., and even this figure is believed to have been improved upon.

The article from which we have quoted appeared in February. Quite recently, Mr. Hesketh put his views more fully before his brother engineers by the reading of a paper at the Northern Society of Electrical Engineers on the same topic. We are told that to permit two different types of generating plant to be put down in one building is most illogical and inefficient; that the alternating arc is not so efficient as the continuous current arc, and that, therefore, the true solution of the difficulty is the adoption of rectifiers.

It is needless to again describe the construction of a rectifier. We have previously gone fully into the question, and illustrated the apparatus when depicting the peculiarities of certain central stations. Of these, perhaps, the names of Portsmouth and Islington might be mentioned as examples.

Coming back to Mr. Hesketh's paper, it may not be out of place to remind those who read it, as given elsewhere in this issue, that efficiency is by no means the only attribute which an electrical engineering appliance should possess. Bearing in mind that we are speaking of rectifiers, we should say that the cost per annum per arc lamp is the only true basis of comparison between one and any other system. The mere efficiency of a rectifier is but a single one out of a very large number of important requirements to be met by such an apparatus. For example, the brushes should not wear rapidly (for brushes of the kind used are expensive, and there are eight commutator, two motor, and two collector brushes on each piece of apparatus);

the operation of the motors when starting up should not affect the incandescent lighting supplied by the same machine; the motors should not be liable to fall out of synchronism, or the current to carry over on the commutator (as even an arc-lighter will do occasionally), and the attendance and attention required should not be such as to add to the wages bill, or appreciably influence this item in the station costs. On these points we learn little from what Mr. Hesketh has to tell us. Synchronous motors are sufficiently well known for their characteristics to be matters of everyday conversation, and what the station engineer wants to know is, how do the motors used to run rectifiers behave in regular work? As to efficiency, from the paper we learn that the former 86 per cent. has now been raised to 90 per cent. This is a very good showing for an apparatus whose regulating properties are dependent upon magnetic leakage; in one which, to regulate well, must be inefficient, and which can be run on short circuit without the normal current being exceeded by 10 per cent.

M. André Blondel, whose researches and writings on questions of lighting and illumination are now fully appreciated in this country, has recently contributed some articles to *La Révue Technique*, in which he refers to rectifiers. It must, says he, be thought that the Ferranti rectifier will not have the same defect as the old commutatored alternators—that of rapid deterioration of the commutator by reason of the sparking, though it is very difficult to commute currents in circuits with self-induction without strong sparking. This particular trouble, we understand, is not a trait that rectifiers usually possess. M. Blondel also thinks it quite possible that the luminous efficiency of rectified arcs will be somewhat less than that of a direct-current arc. Mr. Hesketh, on the other hand, says: "The illumination from a rectified arc is not perceptibly different from that of a continuous arc," but does not give any authority. The excellent illumination at Portsmouth is, however, the best answer to any question of this sort.

Now, to sum up the whole question. If any one be called upon to light say 50 or 200 arc lamps for public illumination, the question is, which is the most satisfactory and economical way of doing this in the long run? Extinctions due to idiosyncracies of plant must be guarded against, capital expenditure must be kept reasonably low, and the cost per arc lamp per annum, taking all things into consideration, should be a minimum. Alternating arcs have a low luminous efficiency, but they can be run direct off very efficient transformers, and no extra plant is required in the station. Continuous arcs require separate plant, with added cost for coal, water, and oil, and attendance. Rectified arcs require special appliances, but no prime mover. Which, then, at the end of a year, would prove the cheapest light for light? This question cannot be answered yet. Mr. Hesketh has given his answer, and put some figures on paper to support it; but we are surprised to find that even he neglects the financial side of the question. That continuous arcs give a higher C.P. than alternating arcs for the same power is only a little bit of the whole argument. What can be expected of rectifiers will, however, speedily be shown now that a large number are at work, and many more are, we believe, placed on order with the makers.

The London County Council and the Tramways.

SINCE penning our article on "The London County Council and the Tramways" in our issue of May 15th, we have been favoured with copies of the letters which the County of London Tramways Syndicate, Limited, had addressed to the County Council since October 21st, 1895. We have since carefully perused the communication of that date, and three others of April 22nd, April 30th, and May 6th of the present year. We have also had the object of the Syndicate eloquently expounded by one of its members, but we confess that we cannot see either in the correspondence or in the verbal information imparted to us any justification for changing the attitude taken in the REVIEW of the 15th. The indefiniteness of the offer of the Syndicate from the business point of view is fairly shown in the letter of April 30th by the possibilities, probabilities, and doubtful observations in the sixth paragraph of that letter. The shareholders of the unexpired sections of tramline may do the reasonable and come in like lambs, but they may not, and, anyhow, we fail to see how the Highways Committee can, as a matter of business, take the proposal into account in such form. If the Syndicate had already obtained possession of the lines they might ask for a lease with reason, but to ask for a lease "as, and when the lines fall in," on the assumption that the power thus acquired will enable them to obtain earlier possession, is not reasonable. As to the profits from changing the method of traction, we specially note the final paragraph of the letter of April 22nd to the clerk of the Council. "There is no case on record, &c., where the traffic has not increased 10 per cent, and cost reduced 10 per cent." But this is on the method of electric traction recommended by the REVIEW, not by the Syndicate! On the whole it seems that our article of the 15th inst. gives a very fair view of the situation, and we think it would be a pity to let it be supposed that electric traction for London is dependent on the success of the Syndicate. But be this as it may, if any contrary arguments are to be urged, we shall be glad to give place to them in our Correspondence columns. Editorial comment thereon might be utilised for clearing misconception, if any exists outside the Syndicate. The aim and object of the ELECTRICAL REVIEW, for many years past, has been the legitimate development of electrical traction in this country, whether by means of accumulators, overhead wires, or conduit systems, and we have steadfastly lent our support to any scheme which had the semblance of success in it; we trust, therefore, that the position we have taken up in this particular instance will not be misunderstood by those who have the real advancement of a great branch of the electro-technical industry at heart. To point to one or two instances of conduits being used more or less successfully abroad is scarcely good enough to induce the London County Council to give up the streets of London to a method of working which, not suited to all localities, and admittedly very expensive under the best conditions, may, in the absence of any experimental proofs to the contrary, turn out a huge technical and commercial blunder. We would rather urge upon the Council the advisability of not leasing the lines at all, but making such arrangements as will enable them to undertake the working themselves; or, if they are not at once prepared for this, to postpone the consideration of the entire question pending further enquiries.

The Bedford Fatality.—The inquest on the body of A. E. Christmas (also known as Bates), who met his death in a sub-station of the Bedford Sanitary Authority, on 15th inst., was held last Saturday in the Corn Exchange. A verdict of "accidental death by an electric shock" was returned by the jury. A Board of Trade inquiry is to be held.

ON SECONDARY BATTERIES FOR ELECTRICAL LOCOMOTION.

By DESMOND G. FITZ-GERALD.

(*Continued from page* 589.)

The question that next arises, after that of obtaining the active material in the most suitable form, is the very important one of establishing the most perfect and extended contact with the active material. In the case of the peroxide, the only metal known to be practically available for that purpose on a large scale is lead, which may not disadvantageously be alloyed with a small percentage of antimony. In the case of the spongy lead, copper has sometimes been used; being protected from chemical action so long—and only so long—as any metallic lead in the spongy form remains in contact with it. Experiments have also been in progress for some time past with a view to the substitution for lead of other metals having a lower specific gravity. Persistent endeavours, moreover, are still being made to carry into effect the substitution of zinc for spongy lead, as the electro-positive element of the secondary couple, which has been attempted by Reynier and Tamine.

In establishing the contact, we have absolutely to limit the *current-density* to a certain maximum which has to be determined. This is essential to avoid undue heating and disruptive effects. The conversion of energy into heat—not necessarily resulting in rise of temperature—must be avoided also by reducing as much as possible, the length of electrolyte traversed by the current. In the case of batteries for locomotion, we have to divest ourselves of the notion that the easiest, most convenient, and most obviously practicable means of establishing contact is the one to be adopted. "*Le mieux est l'ennemi du bien*," says the old French proverb, which ordinarily means "leave well alone." It must here be taken in a different sense. We have some secondary batteries which, when carefully used, answer well—even very well—for many ordinary purposes. They are wonderfully cheap, well made, and sometimes even well-designed—for these purposes. But, for reasons that have been partly and have to be more fully exposed, they are *not* adapted—not even in many cases with modifications—for electrical traction. To obtain a battery adapted for that purpose is a difficult task in which we have to play a game with Nature herself (who is not kind to those who make mistakes), and in this game we cannot afford to make even a good move, if a better be possible.

We shall not be puzzled by having to consider a large number of different methods of establishing contact with the active material. The available methods may be considered under two heads—the grid and the imbedded conductor.

To fix the ideas, as the French say, we may illustrate the two methods by figs. 1 and 2. The former may represent, not only the "pasted" grid, but that which is cast around pellets or small slabs consisting of, or to be converted into, active material. The latter may represent all elements in which the active material is wholly external to the support or conductor, which we may suppose to be either plain, grooved or corrugated, or in the form of wires woven or otherwise.

The uncompromising advocate of the grid support would probably maintain that a much more extended contact with the active material, with lower resistance and current density, is obtained in method No. 1 than in the other. He would have, moreover, a *primâ facie* case that the latter was fully tried and found wanting; and he might hold that any further attempts to render it practicable must be futile and mischievous. He might refer to the statement by Reckenzaun* that "Unfortunately, the active materials will not adhere perfectly to metallic sheets, and this deficiency of good contact reduces the capacity. This explains why Faure employed more than double the amount of paste for a given capacity than is being used by makers of perforated plates." And he might hold, with some amount of plausibility, that this difficulty of non-adherence must be a fatal one in the case of any resuscitation or modification of the original method, and one not to be overcome by any system of casing or packing the elements.

* Electrical Review, Vol. XIX., p. 608.

In regard to the fundamental objection, I must point out, first, that such methods of construction as those adopted in the Tudor and Epstein accumulators are included under fig. 2; and, secondly, that experimental results are gradually accumulating in support of the conclusion that, when certain precautions are adopted in "forming" the (peroxide) active material, modes of packing other than that adopted in the grid support may be quite as efficacious in maintaining contact with the active material. At the same time—and this is one of the main inducements not to "leave well alone"—evidence is accumulating, not only in the laboratory but in practical work, that an embedded conductor may be protected to a very great extent from the effects of local action, involving not only corrosion and comparatively rapid destruction, but also continuous loss of energy. Moreover, such a conductor is safe-guarded against buckling and warping.

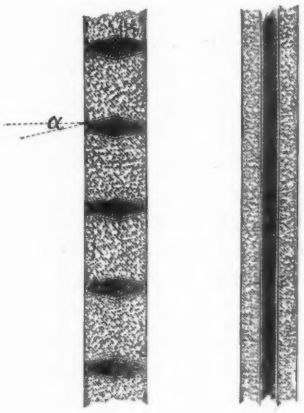


Fig. 1. Fig. 2.

These advantages, however, would be heavily discounted if it were the fact that a much larger surface of contact between the active material and the support is afforded by the grid than by the embedded conductor.

The question is well worth investigation.

Case 1.

Let s = this surface of contact.
a = the area of the active material on one side of a grid.
t = the thickness of the grid or element.
n = the number of plugs or small slabs in the grid,
and α = the angle of slope (see fig. 1) of apertures in grid,

then $$s = \sqrt{\frac{a}{n}} \times \frac{4}{\cos \alpha} \times t \times n.$$

Note.—Here we see that, *cæteris paribus*, the surface of contact varies as $\frac{n}{\sqrt{n}} = \sqrt{n}$; so that, in the case of a grid for rapid discharge, the value of n should be as large as possible. On the other hand, the ratio of inert to active material tends to increase with n.

Case 2.—In the case of an imbedded conductor:
Let A be the total area of one side of the conductor, then

$$s = 2A.$$

Now, let us take for comparison—two elements, one of each kind, equal in size. The grid, as we have seen, should be one in which the number of plugs (n) in a given area should be comparatively large, but not so large as either to render the grid unduly heavy, or, on the other hand, to diminish unduly the thickness of the metallic partition between the plugs of active material. Perhaps we cannot do better than to take a peroxide plate of the accumulator [(*a*) cell used for locomotive purposes] referred to by Reckenzaun in his "Practical Notes, &c."* It is true that the cell in question was in use ten years ago, and that grid accumulators have been improved since that period. But, although the more recent accumulator may be on the whole a better one, I do not think it would have, in practical use, a

* See Electrical Review, Vol. XIX., p. 584.

higher capacity than that corresponding to 13 ampere hours, or a higher rate of discharge than that corresponding to 4 amperes, per pound of active material. Nor, except perhaps, in E.P.S. cells of the K type, would the surface of contact with the active material be greater for a plate of given weight. For the purpose of comparison with an element having an embedded conductor, it will not, in a word, be unfair to consider the old form of plate as used by Reckenzaun.

A portion of the grid in question is shown in fig. 3.

Case 1.—The following values apply to the peroxide element :—

A = total area of one side of plate ...	·264 sq. ft, 38 sq. in.
a = area of active material, one side of plate	·186 „ 26·85 „
t = thickness of plate	$\frac{1}{18}$th in.
n = number of plugs (square slabs) ...	560
w = weight of peroxide in plate	·552 lb.
v = volume „ „ „	3·35 c. in.
$\frac{a}{n}$ = exposed surface of each plug, one side	·048 sq. in.
$\sqrt{\frac{a}{n}} = \sqrt{·048}$ = length of side of plug or grid aperture	·219 in.
$\sqrt{\frac{a}{n}} \times t$ = area of side of plug or grid aperture	·05475 sq. in.

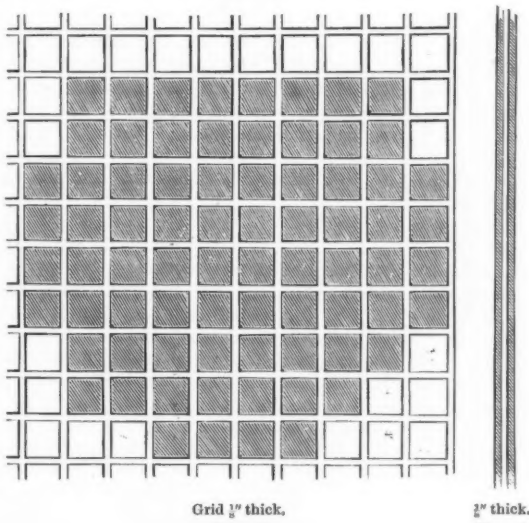
and

$S = \sqrt{·048}$ in. $\times 4 \times \frac{1}{8} \times 560$ ... = 61·3 sq. in.

Case 2.—Taking the same value for A, viz.: 38 square inches, $S = 2A = 76$ square inches.

Thus in the plate with an embedded conductor, shown in section by fig. 4, the surface of contact between the conductor and the active material is about 24·6 per cent. greater in the plate with the embedded conductor than in the grid element. To obtain the same surface of contact in the grid, the number of plugs would have to be increased from 560 to 870, thus :—

To Scale.



Grid $\frac{1}{8}$" thick.

FIG. 3.

$\frac{1}{8}$" thick.

FIG. 4.

$$61{\cdot}3 \text{ square inches} : 76 \text{ square inches} :: \sqrt{560} : \sqrt{x}$$

$$x = 29{\cdot}5^2 = 870{\cdot}25.$$

And, practically, this increase in the number of plugs could not be carried into effect without increasing the ratio of inactive to active material in the "pasted" grid.

It is to be observed, moreover, that, in the Epstein and Tudor accumulators, for instance, the surface of the embedded or coated plate is more or less deeply grooved, so as to augment the value of S. It is claimed that, in the improved Tudor cells, types P and T, the surface of contact between the conductor and the active material is about seven times that of a plain plate having the same outside dimensions. At the same time, it should be pointed out that extending the surface by this means does not necessarily, or generally, affect the important condition of "density" of current.

Let us, for the sake of a more perfect comparison, make the weight of the embedded conductor, a portion of which is shown in fig. 4, equal to that of the grid, partly shown in fig. 3.

The volume of a plate of lead $\frac{1}{18}$-inch thick, and having the superficial area on each side of 38 square inches, is 4·625 c. in. Taking the weight of 1 c. in. of lead as ·41 lb. this solid plate would weigh $4{\cdot}625 \times {\cdot}41 = 1{\cdot}896$ lb. Then the weight of the grid (with square perforations) will be—

$$1{\cdot}896 \times \frac{A - a}{A} = {\cdot}55 \text{ lb.}$$

Now the thickness of the (embedded) plate of area (on one side) 38 square inches will be—

$$t = \frac{{\cdot}55 \text{ lb.}}{38 \text{ square inches} \times {\cdot}41} = {\cdot}0353 \text{ inch.}$$

Let us compare this with the thickness of the lead partitions separating the plugs of active material.

The total area (A) of one side of the grid element being 38 square inches, and the side of the square of this area being $\sqrt{38} = 6{\cdot}164$, and the area of active material (one side) being 26·85, the aggregate lengths of active material along one side of the element will be $\sqrt{26{\cdot}85} = 5{\cdot}19$ inches. This, divided by the side of the plug or slab, gives the number of such plugs along one side of the square,* viz.,

$$\frac{5{\cdot}19}{{\cdot}219} = 23{\cdot}7.$$

The number of partitions between the plugs, with the two terminal divisions, will be this *plus* one or 24·7, and the thickness of the dividing partitions will be—

$$\frac{\sqrt{A} - \sqrt{a}}{24{\cdot}7} = {\cdot}039 \text{ inch,}$$

i.e., somewhat greater than that of the embedded conductor But the latter, instead of having 11·15 square inches of its surface in direct, or nearly direct, contact with the electrolyte *is protected* from its action in a degree which is mainly dependent upon the density of the active (peroxide) material. A curious and very prevalent misconception, under which this protection from local action and consequent corrosion and waste of energy is entirely ascribed to the clogging effect of sulphate of lead, will be referred to later on. We have now to calculate the thickness of the layer of active material distributed over the two surfaces of the embedded conductor.

The area of these two surfaces $= 2A = 76$ square inches, the volume (v) of active (peroxide) material is 3·35 cubic inches, and the thickness of the layer will be

$$t = \frac{v}{2A} = {\cdot}044 \text{ inch.}$$

The total thickness of the element (fig. 4) of the same weight as the grid element (fig. 3), is thus

$${\cdot}035 + {\cdot}044 \times 2 = {\cdot}123 \text{ inch}$$

or $\frac{1}{8}$ inch nearly.

It will be interesting to note the rates of discharge obtained by Reckenzaun with the above grid element weighing 1·102 lb. or (say) 1 lb. $1\frac{3}{5}$ oz. The period of discharge was 3 hours, the maximum current 5·06 amps., the mean current 4·16 amps., and the maximum (final) current 3·69 amps. The final E.M.F. was 1·87 volts. Taking the mean current, the rate of discharge per lb. of peroxide was 7·54 amps., or per lb. of active material (including spongy-lead) nearly 4 amps. The rate of discharge per lb. of peroxide *plate* was 3·8 amps. nearly.

But what concerns us more particularly is the *density* of the current of discharge. If this be too great, not only does the rise of temperature become inadmissible, but the peroxide element, more particularly, is liable to destruction through the disintegration of the active material. Amperes per square inch of surface or section at right angles to the current may be taken practically as a measure of current density. In calculating density of discharge current at the surface of an element, active surface only must be considered.

* The plate was not really square as is here assumed; but a rectangle with sides about 7·3 inches and 5·21 inches respectively.

Thus the density of the mean current of discharge, as above, at the surface of the grid element (fig. 3) would generally be

$$\frac{4{\cdot}16}{2\,a} = {\cdot}077\,;$$

the maximum average density now allowed for grid plates being about ·046—though a much higher density is permissible for a short period of time.

In the case of the imbedded plate element (fig. 4) the density for the same current would be:

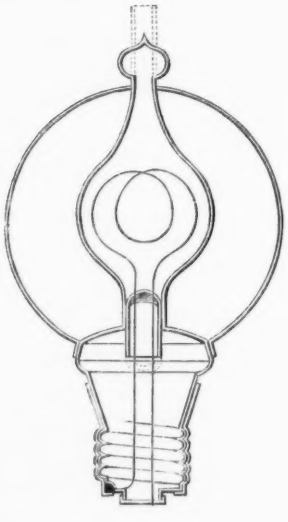
$$\frac{4{\cdot}16}{2\,A} = {\cdot}0547,$$

which I should consider high, corresponding as it does to 1·42 cubic inch of hydrogen oxidised per hour per square inch of active surface.

A NON-BLACKENING INCANDESCENT LAMP.

THE *Electrical Age* for April 11th contains a description of an incandescent lamp which, it is asserted, does not blacken on running. To speak more correctly and specifically, the obscuring matter given off by the filament is caused to deposit in a small additional bulb blown on to the exhaust tube of the lamp, and thus the evil effects are not felt. The invention is due to Mr. F. M. F. Cazin, of Hoboken, N.Y., and if the claim made can be substantiated, it must be admitted that the inventor merits considerable distinction from a scientific, if not from a practical point of view.

The desired result is achieved by surrounding the lamp bulb proper by a second non-exhausted bulb, which thus encloses a limited quantity of air round the lamp. The small additional bulb, which is blown on the exhaust tube after placing the outer bulb in position, is alone exposed to the cooling influences of the air. When running the lamp, the air enclosed between the bulbs becomes highly heated, and so keeps the inner bulb at a high temperature, and the interesting point is, so we are told, that the carbon vapour given off



from the filament does not condense on the heated glass, but finds its way to the distant and cool bulb. The idea and device shown by the annexed figure are certainly highly ingenious, and very pretty, and we hope this is not the last we shall hear of them and the principles involved. There are, however, certain passages in the article which unfortunately have the tendency of somewhat damping our enthusiasm. "That cooling effect does in fact cause locally increased deposition, is a matter of everyday experience. Incandescent vacuum lamps exposed to air-draught from often open door or window, and the position of which lamps is not changed, show always increased deposition and blackening on the exposed side of the bulb." It is true we have not given attention to this "matter of every-day experience," and we may therefore be pardoned if we are in error when we hint that this explanation of irregular blackening seems a little imaginary, and suggest that perhaps the observers who have advanced the view may not have sufficiently considered certain other known causes of local blackening—such as the unsymmetrical shape, the non-central position, or the spotty or patchy condition of the filaments.

The article proceeds:—"It is true that some nice theories have been advanced other than evaporation and condensation, but the causes quoted for these theories do, on investigation, not hold good. The spoiled filament under the microscope is not different essentially from the filament used, as it appeared previous to being flashed to the intended resistance. It is the product of the flashing which volatilises mainly, the deposited substance being mainly the same as the substance deposited on the filament by and in the flashing process, a fact of which advantage is also taken in the new lamp, by preparing the filaments therefor at a reduced rate of flashing." That the deposited film mainly consists of the carbon deposited in flashing is probable, since the specific resistance of that portion is lower than the core, and therefore becomes more highly heated when running; but what the writer of the article means by saying that advantage is taken of this fact by preparing the filaments at a reduced rate of flashing, is a little difficult to conjecture. The claim is further made that, owing to decreased wasted parts in fitting the lamp together, it can be made more cheaply than the one in universal use. Complication of parts and details in articles like incandescent lamps is not usually attended with this result, and it is not easy to see how the claim of decreased cost can be verified in the device as presented.

The article concludes with the announcement of another and quite new lamp of Mr. Cazin, which, when perfected and produced, should create a veritable sensation. After referring to plans for negotiating the patent of the non-blackening lamp, the article continues:—"It is proposed to reserve the use only of the patented features of this lamp for the same patentee's other new lamp, the luminous body incandescent lamp, which is now being brought to its practical shape and perfection.

"In this other new lamp, of which we shall further speak on another occasion, the same substances, the oxides of thorium and cerium, are used that form the webs in the Welsbach gas lamp for increase of light, in form a sheet or body, in or on the face of which the filament or filaments appear as an integral part, and which sheet, manufactured under new methods, is made incandescent by the dark heat rays emanating from the filament or filaments under current. And the reserve is made because the double globe and local deposition is applicable to the luminous body lamp, the same as it is to all other incandescent vacuum lamps.

RECENT EXPERIMENTS WITH THE GLOBULAR DISCHARGE.

(*Concluded from page* 611.)

THE most curious modifications of the luminous masses are obtained by introducing into the discharge tube a mixture of gases or vapours. Nothing of importance, however, is obtained by mixing gases in which the globular discharge cannot be excited, nor from mixtures in which these gases preponderate. Consequently only the results will be recorded, which were obtained by Righi when the gas contained in the discharge tube was principally composed of nitrogen or carbonic oxide.

For these experiments, it is convenient to fuse on to the discharge tube, T (fig. 4), a glass apparatus, consisting of a horizontal tube, A, B, connected at A to a manometer and closed at B by a special glass tap, which has been already mentioned, and by which it is possible to introduce into the tube small quantities of gas or vapour. This tap is connected, on the right side, by means of a mercury joint, M, to

a glass receiver, S, destined generally to contain a liquid, the vapours of which are to pass into the tube, T, or else to contain a gas; at the two extremities of the receiver are placed taps, P and Q, of which the use is evident. Lastly, three lateral tubes, C, D, and E, furnished with taps, are connected to the tube, A, B. One of these lateral tubes communicates with the air pump, and the others with gasometers containing the gases which are to be introduced into the tube, T.

It is easy to understand, without further explanation, how a mixture of two or three gases, one of which may be the vapour of the liquid contained in S, may be introduced into the tube, T, and how every trace of air or moisture may be driven out. When the vapour of the liquid contained in S has a low tension, a certain quantity of one of the gases is to be introduced into the tube, T, in order that the pressure in S may always be a little higher than that in the tube, T, without which the vapour will not pass quickly through the tap, T.

By reading the manometer it is possible to produce in the discharge tube definite mixtures of gases; but in most cases the quantity of gas or of vapours that it is necessary to add to nitrogen or carbonic oxide in order to obtain the effects to

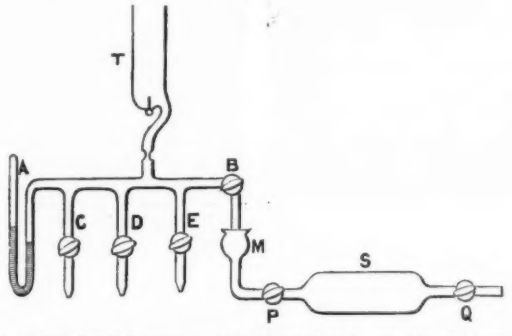


Fig. 4.—Experimental arrangement for the study of the globular discharge in gaseous mixtures.

be described is too small to be measured, and it is necessary to proceed by repeated trials. When the desired effect is obtained, the tube, T, is fused off at the narrow end of the connecting tube.

The following are, in few words, the most salient peculiarities observed when the globular discharge is produced in mixtures of gases.

Nitrogen and Carbonic Oxide.—With mixtures of these two gases, the globular discharge differs from that which is given by each separately, only in the colour of the light. It is to be noted that as long as nitrogen does not absolutely

Fig. 5.—Globular discharge in a mixture of nitrogen and carbonic oxide at a pressure of 19 mm.

Fig. 6.—Globular discharge in a mixture of nitrogen and methane at a pressure of 16 mm.

predominate, the mixture behaves as if carbonic oxide alone was present. A mixture of 15 parts of nitrogen and one part of carbonic oxide gives a white violet colour, but if the amount of the second gas is slightly augmented, the colour becomes green. With 32 parts of nitrogen and one part of carbonic oxide, the light emitted by the luminous mass is feebly rose coloured; with 64 parts of nitrogen and one part of carbonic oxide, the colour is rose, and it is necessary to diminish to a much greater extent the quantity of the second gas for the discharge to get the red colour peculiar to pure nitrogen.

As to the form of the luminous mass, it differs a little from that observed with nitrogen. Fig. 5 ($P = 19$ mm., $p = \frac{1}{2} s$) shows one of these masses in a mixture of 15 parts of nitrogen and one part of carbonic oxide.

Nitrogen and Hydrogen.—This mixture behaves very much like the preceding.

Nitrogen with Small Quantities of other Gases or Vapours.—*Air.*—If a small quantity of a gas or a vapour which by itself does not give the globular discharge, or which only gives luminious masses of great velocity, is added to pure nitrogen, the following effects are observed :—

The luminous mass diminishes more or less in size, varies also in form, but, above all, increases in speed.

With successive additions of another gas, an increase of speed of the luminous mass is, first of all, noted, though it is still possible to follow it with the eye; but, by-and-bye, the movement becomes so rapid that it can only be observed in the revolving mirror. As the quantity of the other gas is increased, the discharge finally takes the form of an ordinary spark, and the luminous mass can no more be seen, even in a very rapid revolving mirror.

Besides this visible modification, the potential necessary for the formation of the globular discharge increases, other things being equal. With each fresh addition of the foreign gas it is necessary, then, to increase the explosive distance of

Fig. 7.—Globular discharge in a mixture of nitrogen and illuminating gas at a pressure of 11 mm.

Fig. 8.—Globular discharge in a mixture of nitrogen and bromine at a pressure of 15 mm.

the spark in air, or it is necessary to diminish the resistance of the discharge circuit; these two conditions, as has been already explained, compensating one another.

In the mixture of nitrogen and oxygen which we have in atmospheric air, higher potentials than in pure nitrogen are necessary to produce the globular discharge. The luminous masses in air are of a red or purplish colour; they are more elongated, and move more rapidly than in nitrogen.

In the case of atmospheric air, the quantity of oxygen mixed with the nitrogen is considerable; but, in the case of other gases, a much smaller quantity profoundly modifies the phenomenon.

Nitrogen and Methane.—Fig. 6 ($P = 16$ mm., $p = \frac{1}{2} s$), represents the globular discharge in nitrogen containing a small quantity of methane. As can be seen, the luminous mass is very large at the upper part, and is accompanied by an aureole of light of less intensity. Its colour is no longer purple red, as in nitrogen, but red with a violet tinge.

Nitrogen and Illuminating Gas, Acetone, &c.—A small quantity of illuminating gas added to nitrogen gives rise to a phenomenon of the greatest interest. The luminous mass, fig. 7 ($P = 11$ mm., $p = \frac{1}{2} s$), is still shorter and more rounded than in the preceding case. Besides the pale aureole of light which surrounds it, takes the form of an ellipsoid, which for certain pressures, and certain added quantities of the illuminating gas, can become almost exactly spherical.

By producing a prolonged discharge, and making the resistance of the circuit of discharge not too small, the luminous mass, once produced, remains immovable in the tube, and is visible as long as the electric machine is in action. Two or more luminous masses distributed along the axis of the tube may sometimes be obtained by properly augmenting the potential. Soon, however, the last mass formed retreats towards the positive pole, and disappears there. At this instant the other luminous mass, which was fixed till then, also moves towards the positive electrode, hops

briskly, and then remains permanently immovable and visible.

If the illuminating gas slightly exceeds the necessary quantity, the luminous mass flattens itself from above downwards, and becomes unstable. During its presence in the tube it oscillates more or less rapidly in the direction of the axis of the tube in an irregular and curious fashion.

By substituting for illuminating gas vapours of acetone, chloride of ether or acetate of ethyl, analogous phenomena to those just described may be obtained.

Nitrogen and Sulphuretted Hydrogen.—Nitrogen, with some traces of sulphuretted hydrogen, produces very brilliant but unstable phenomena, which is evidently owing to chemical modifications of the mixture. The luminous masses are red below, and azure at their other extremity. With certain proportions between the two gases, they assume the form of a comet, *i.e.*, they have an azure nucleus and a red tail, which diverges from it.

Nitrogen and Bromine, Bromide of Ethyl, &c.—Mixtures of nitrogen, with small quantities of bromide of ethyl, bromine, iodide of ethyl and acetylene, give luminous masses, which, for certain values of the pressure, have forms very different from those which we have hitherto described. It is especially with the vapour of bromine that characteristic effects are obtained; but the tubes used, containing nitrogen and traces of bromine, deteriorate with the lapse of time, and after some weeks or some months, they behave as if the great part of the bromine had disappeared. It is preferable, therefore, to experiment with a discharge tube connected to the apparatus shown in fig. 4. At a convenient pressure, which is sensibly that of the minimum speed of displacement of the luminous mass, they are very brilliant, much smaller than in pure hydrogen, have a greater speed of translation, and lastly, they have the form of cones with their bases directed downward, *i.e.*, towards the positive electrode.

Fig. 9.—Globular discharge in a mixture of nitrogen and bromine at a pressure of 15 mm.

Fig. 10.—Globular discharge in a mixture of nitrogen and bromine at a pressure of 15 mm.

Fig. 9 represents one of these conical masses in its natural size (P = 15 mm., $p = \frac{1}{85}$ *s*). It is very bright at the point, and becomes gradually less luminous towards the base; it is surrounded by a pale auréole, especially towards its summit. Fig. 6 (P = 15 mm., $p = \frac{1}{85}$ *s*) and fig. 8 (P = 15 mm., $p = \frac{1}{85}$ *s*) represent, on a scale, $\frac{2}{3}$rds of their own size, other luminous masses of the same form.

By increasing a little the spark gap of the exciter, or reducing the resistance, we obtain, instead of the simple discharge, a multiple discharge, comprising a great number of luminous cones, emanating one after the other from the positive electrode. The phenomenon is then truly beautiful to look at, especially when the experiment is made in semi-obscurity. Looked at from some distance, it has exactly the aspects of the well-known fireworks called Roman candles.

This faculty of producing several successive luminous masses for each discharge remains, even when the proportion of bromide is slightly diminished. This diminution has chiefly the effect of rendering uncertain the contour of the cone at its point, in such a way that it is finally confounded with the auréole. The luminous mass, fig. 11 (P = 14 mm., $p = \frac{1}{85}$), is somewhat like that which is obtained in pure nitrogen.

The production of conical luminous masses necessitates a certain pressure of gas. If that is diminished, the masses become larger and more diffuse; if it is increased they become elongated, and the point of the cone blends into the auréole, as in the case of an insufficiency of bromine. Fig. 12 (P = 20 mm., $p = \frac{1}{85}$ *s*) represents the appearance which they then present.

Figures 8, 11, 12 and 13 represent luminous masses produced in a tube of larger dimensions than ordinary, the length of which was 57 cm., and the diameter 5·5 cm.; in smaller tubes the luminous masses are simply smaller and more brilliant. But the large tube shows sometimes a phenomenon which has never been obtained in smaller tubes. The luminous mass, in elongating itself from the positive electrode, remains, sometimes, connected to it by a long and brilliant luminous column, which can be seen in fig. 13 (P = 16 mm., $p = \frac{1}{85}$ *s*). When this column disappears, the luminous mass becomes free, and continues its movement.

Fig. 11.—Globular discharge in a mixture of nitrogen and vapour of bromine at a pressure of 14 mm.

Fig. 12.—Globular discharge in a mixture of nitrogen and bromine at a pressure of 20 mm.

Nitrogen and Tetrachloride of Tin.—In nitrogen containing a feeble trace of the vapour of tetrachloride of tin, the phenomena are very beautiful; their richness and variety cannot be described. When only the brilliant discharge is produced, there is seen in the tube a column of pale colour, green or azure, according to the potential, resistance, &c. When, afterwards, the globular discharge is produced, the luminous mass, of a rose or red colour, takes various forms according to the pressure and the proportion of tetrachloride; it changes frequently during its movement. Thus, at the pressure at which the luminous masses move at the slowest speed, each mass has directly after its formation the conical form described above; but immediately after, while it is

Fig. 13.—Globular discharge in a large tube at a pressure of 15 mm.

travelling towards the cathode, it changes its form gradually, by increasing in dimensions, till near the end of its course, it assumes the same form as in pure nitrogen, or in a mixture of nitrogen and illuminating gas.

Carbonic Oxide and Small Quantities of Another Gas or Vapour.—The addition of a small quantity of some other gas than nitrogen, to carbonic oxide, gives rise to effects

similar to those which are obtained with the same additions to nitrogen. Likewise in this case, the potential necessary to produce the globular discharge increases with the quantity of gas introduced, other conditions being the same. The form of the luminous mass appears to vary in the same way as in nitrogen. Thus, if there is added to the carbonic oxide a small quantity of the vapour of bromine, luminous masses which have the conical form of fig. 9 are obtained. Their colour is green, instead of red, as in the case of nitrogen; but they are equally brilliant, and present the same characteristics.

Tubes containing a mixture of carbonic oxide and bromine, when once prepared and sealed, keep much longer than those containing nitrogen and bromine. Tubes prepared in this way have shown no sensible change after four or five months.

Conical luminous masses of white colour may be obtained by adding traces of bromine to a mixture of nitrogen and carbonic oxide.

Righi does not attempt, at the present stage of his investigations, to give a complete theory of these curious and interesting phenomena, but the results obtained appear to support an explanation given in a former memoir (already cited), which relate the globular discharge in gases to discharges in liquids.

A phenomenon, which may be predicted from this relation, is the production of globular discharges at a distance from the electrode, and exactly where the gaseous column presents an abrupt reduction of its section. An experiment which shows this phenomenon may be made by using a glass

Fig. 14.—Tube with electrodes for the globular discharge.

tube (fig. 14), furnished with electrodes, A and B, 60 cm. in length and 4 cm. wide, and containing nitrogen at a pressure of 14 mm. This tube is reduced in section at C, about one-third of its length from B; the diameter of its interior section at this point is reduced to about 2 cm. When the discharge passes, the contracted part, C, becomes luminous, and at the same time behaves like an insulated metallic wire; the lower part of the contraction acts like a negative electrode, and the upper part like a positive electrode; while a luminous mass forms upon the positive electrode, B, and travels as far as the contraction, another (and frequently two successively) forms at the upper part of the luminosity which fills the restricted part, and advances towards the negative electrode.

Righi considers that the explanation which he has recently given* of the formation of sparks at the surface of liquids may be extended also to sparks in the depths of the liquid conductors or semi-conductors, and consequently, to globular discharges, except that there remains this difference between the two forms of discharge that, whilst the spark at the surface or in the depths of the liquids commences at the electrode, and extends itself without leaving it, the luminous masses, on the contrary, detach themselves completely. But this difference may be considered perhaps, more apparent than real, if it is supposed that the discharge always has an effective existence between the electrode and the luminous mass, even when it is at a distance from it, under the form of an obscure discharge, that is to say, without sensible illumination of the gaseous medium. It is well known that in gases, in different circumstances, such obscure discharges, or regions that the discharge leaves in relative obscurity, may be observed.

Righi thinks it would be rash to attempt a complete explanation of the globular discharge, since this explanation must account not only for the formation of the luminous masses, and their movement, but also give the reason why they can be formed practically in carbonic oxide and nitrogen only. Righi favours the electrolytic theory of the electric discharge, and deduces from that theory that the facility with which the globular discharge is formed in different gases must depend on the facility with which their molecules can be split into atoms, and recombine to form a new molecule, and on the rapidity of movement of the different kinds of free atoms.

Righi's results are so unique, that we have no doubt they will open up a new field research, and a new line of attack on that one of Nature's secrets which still baffles scientific men—the true nature of electricity and the electric discharge.

* *Rend. della. R. Acc. dei Lincei*, t. IV., série 5, March 3rd, 1895.

SURGERY OF NASAL SEPTUM.*†

Electrolysis as a Treatment for Deviations, Spurs and Ridges along the Nasal Canal—Direct Current Therapeutics.

Twenty-one Cases Reported with Results.

My lectures before the National School of Electricity have enabled me to estimate the lack of accurate information among physicians as to the nature of electrolysis as a remedial agent. This is my apology for giving a brief statement of the electrolytic process as an introduction to this paper. Electrolysis is that chemical change or molecular disintegration which occurs when a direct (galvanic) current of electricity is passed through animal tissue or any other electrolyte. If a direct current of electricity be passed through water (H_2O) there is an immediate disintegration of the liquid, oxygen being liberated at the anode (positive pole) and hydrogen at the cathode (negative pole). If this process be continued the entire amount of water in the vessel will be decomposed, and in its stead will be two parts of hydrogen by volume and one of oxygen. This is a simple illustration of the electrolytic action of electricity when applied to a simple electrolyte. If the substance to be decomposed or disintegrated is more complex in its chemical composition it will undergo the same molecular disintegration, but it will be more difficult of demonstration.

When a direct (galvanic) current is passed through animal tissue it is more or less disintegrated, its molecular, its cellular structure is broken up in the immediate vicinity of the poles. Near the anode (positive pole or electrode) oxygen, chlorine and acids are accumulated, while around the cathode (negative pole or electrode) hydrogen and alkalies are accumulated. There is, no doubt, some interpolar change in the tissues remote from the poles, but it is difficult of demonstration. An inflammatory action is excited, osteoclasts are left in the broken-down tissue and absorption takes place through their agency. Where a larger area is entirely cut off from blood supply it sloughs without absorption. The electrolytic power of the current is in proportion to its density, hence, it is usually applied by means of needles as the active electrode, the indifferent electrode being from a few to a 100 square inches in area, according to the quantity of current needed in the case under treatment. In bipolar electrolysis both poles, usually needles, are introduced into the tissue to be destroyed. It should be remembered that electrolysis does not necessarily mean the caustic destruction of tissue, but rather the chemical disintegration of it.

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† From the *Electrical Journal* of Chicago.

There is a primary and a secondary electrolytic action to be taken into account. By primary electrolysis is meant the chemical dissolution of the elements composing the tissue; by secondary electrolysis is meant those changes which occur owing to the presence of the liberated chemicals already referred to. The primary action takes place during the time the current is passing through the tissues, while the secondary action occurs so long as the newly liberated chemicals (hydrogen and alkalies, or oxygen and acids) remain free in the tissues and the osteoclastic absorption is in progress. In some cases it continues active several days. The characteristic reactions occurring at either the positive or negative pole is chiefly due to the peculiar chemic products formed at the respective poles. At the anode we should expect the tissues to be hardened, coagulated, owing to the presence of oxygen and acids about it. At the cathode we should expect the tissues to be softened, liquefied, owing to the presence of alkalies there. A moment's consideration will suggest the wisdom of this law, for a vascular growth needs in addition to the disintegration of tissue to shut off the blood supply of the part, so as to prevent rapid repair of the part, while in fibrous tissue the blood supply is poor and a softening of the tissues is needed to favour absorption through the medium of the phagocytes and circulation. Hence vascular growths are most effectually treated with anodal electrolysis, while firm fibrous growths are best treated with cathodal electrolysis. In some conditions (notably bony and cartilaginous growths) it is indifferent which pole is used locally, or it may be found expedient to use both locally, in order that the current be confined more perfectly to the offending tissue.

The advantages of the bipolar method for operations in the nose are; *a*, the current is limited to the offending tissues and shock from diffusion of current to brain is avoided; *b*, perforation of the nasal septum is avoided as the current is limited to a field superior to the plane of septum, *i.e.*, to the path between needles in the growth; *c*, the method is simple and less painful than the monopolar method.

Specially devised needles may be used or in most cases extra large sewing needles answer every purpose. Moure* has designed a series of double needles to be used in the base of spurs and ridges; whereby he claims superior results are obtained as the current is more uniformly distributed through the growth, thereby favouring its complete removal with a minimum quantity of electric force. All my operations were done with single needles except No. 18. The part of the needle not imbedded in tissue should be insulated with varnish or small rubber tubing to prevent destructive action to inoffensive tissue.

The outfit needed to do electrolysis of bony and cartilaginous spurs and ridges of the nasal septum must embrace the following: *a*, a source of electric energy equal to 25 Leclanché cells—a properly reduced and guarded Edison current may be used; *b*, a reliable rheostat; the Massey current controller answering every purpose; *c*, a reliable milliamperemeter. It would be folly to attempt to do electrolytic work without accurate measurement of the electric energy employed. To depend on the number of "cells turned on" is as absurd as to tell a patient to take 10 pills without regard to the quantity of medicament each represents. Cells used in medical batteries have an electromotive force ranging from 1 to 2 volts, and the resistance of the various tissues of the body varies all the way from 2,000 ohms to 500,000 ohms; hence there is no way of estimating the quantity of current passing through the body

No.	Name.	Age.	Method.	Time mins.	No. M.A.	Spur, ridge, crest.	Effects.—Remarks.
1	Mrs. T.	46	Monopolar	18	18	Cart. spur on right side septum.	At the end of 10 days the spur was disintegrated leaving a smooth surface covered with healthy membrane.
2	Mr. J. P.	28	„	20	18	Bony crest right side septum.	First treatment reduced crest some. Second treatment (one week later) 15 m.a. 15 min. reduced crest enough to overcome stenosis.
3	Mr. W. H.	24	„	25	18	Horiz. 1¼ in. bony ridge right side sept.	Fainted at end of 10 minutes; placed him in reclining position and continued 18 m.a. for 15 min. without further inconvenience. One month later ridge gone and membrane intact.
4	Rev. L.	25	Bipolar.	12	15	Cart. ridge left side.	Two weeks later edges of ridge remaining were removed with a chisel. This required as much work and skill as an original operation with a chisel.
5	Rev. L.	25	„	13	15	Cart. spur left side.	Ten days later spur much reduced and membrane intact. Spur was quite small and of soft cartilage.
6	Miss G.	30	„	12	15	Cart. spur left side.	Large flat needle used at base of spur. At end of one week spur was much reduced and membrane intact.
7	Mr. J. R.	26	„	15	15	Cart. and bony ridge left side.	Eleven days later ridge gone, but there was an offensive odorous discharge from seat of operation. Passed probe 1½ inches back between walls of septum. Twenty gr. argent. nit. checked necrotic process in three weeks.
8	Mr. L.	29	Monopolar	13 27	27 20	Ant. cart. spur left Post. rdg. bone.	A cathodal needle was inserted into each growth, a large sponge electrode being held in the hand of the patient. At end of 13 minutes needle was removed from ant. spur, in 27 min. from post. ridge. One mo. later ant. S. gone, post R. reduced.
9	Miss E.	20	Bipolar.	20	20	Large spur left side cart. and bone.	After two weeks, spur gone and membrane intact.
10	Miss E.	20	„	12	15	Med. cart. spur right side.	After two weeks, spur gone and membrane intact.
11	Mr. E. S.	26	„	20	15	Cart spur right side.	For 15 days sloughing with foul odour; no perforation. At end of one month healing complete. Result good.
12	Mr. E. S.	26	„	13	13	Small cart. spur left side.	At end of two weeks spur was gone. No ill result.
13	Miss P.	21	„	16	14	Large cart. right side.	At end of two weeks spur was gone. No ill result.
14	Mr. C. W.	18	„	18	15	Cartilaginous ridge on right side septum.	Negative needle inserted one inch into ridge. Positive into crest of ridge. At end of first week ridge much reduced.
15	Mr. F. R.	50	„	20	15	Very large cart. spur right side.	At end of second week spur much reduced. Formerly there was great stenosis, now breathing channel was clear.
16	Mr. J. M. B.	25	„	20	15	Horiz. ridge, cart. and bone 1¼ inch long left side.	Negative needle inserted one inch into ridge, positive inserted into crest. After three weeks ridge almost gone, stenosis greatly relieved.
17	Rev. S.	45	„	14	15	Horiz. cart. ridge on right side of septum.	One month later ridge almost gone, membrane intact.
18	Mr. C. S.	32	„	15	10	Horiz. cart. rdg. (ant.) 1½ inch long left side.	Two negative needles used, one inserted into the anterior, the other into the posterior part of ridge. After three weeks anterior part gone, posterior reduced.
19	Mr. V. H.	24	„	16	15	Cart. spur on left side of septum.	At end of second week spur gone and membrane intact.
20	Mr. E. S.	20	„	15	13	Cart. spur right side.	Spur only partially removed, a second operation with a chisel being necessary for its complete removal.
21	Miss P.	21	„	14	12	Small cart. spur on left side.	At end of second week spur gone, membrane intact.

* Archives Cliniques de Bordeaux, February, 1893.

except to measure it with some reliable instrument. The quantity of electric energy required to disintegrate such growths as are of common occurrence in the nose and throat is from 2 to 30 m.a., according to the size of growth and kind of tissue composing it.

In my first paper* it is implied that I was the first American observer to write upon this subject, but I now freely accord Dr. James E. Newcomb, New York, precedence in the field. In the *Medical Record*, August 5th, 1893, he wrote under the title, "Electrolysis for the Relief of Certain Morbid Conditions of the Nasal Septum." He gives an admirable review of the literature to that date with a report of two cases. Since then, there has been little that is new, except some slight modifications in needles and the adaptation of the Edison current to nasal electrolysis by Dr. Casselberry.† He takes the position, in an article read before the American Laryngological Association, at Rochester, that bony growths will not yield to the electrolytic action of the current, contrary to continental observers and also contrary to my own observation.

I present herewith a tabular report of 21 cases in private practice, from which I arrive at conclusions as to the propriety of resorting to electrolysis for the removal of septal spurs and ridges.

These cases were all well nourished, healthy people. An equal number of dispensary cases treated in the same way would, no doubt, show less favourable results. While the results are quite favourable in most cases, the fact still remains that as a method it is neither so simple nor so sure as others at our command. I quite agree with Dr. Bresgen that its scope should be limited: *a*, to those cases in which it is impossible to carry out the usual surgical treatment, either on account of weakness or other disability; *b*, those cases in which more radical measures are refused; *c*, that electrolysis is not, nor can it ever be, a therapeutic measure which can be used by other than experienced specialists, because when carried out by unskilled hands it can only lead to disaster. Dr. Bresgen was supported in his conclusions by Drs. Hajek, Stoerk, Heymann, and Chiari.

I will add the further conclusions: *d*, cartilage yields more readily than bone; *e*, an osteoma is more easily removed than normal bone, because, being an abnormal growth, it is an irritant and is, therefore, more unstable, requiring less irritation to cause proliferation of osteoclasts; *f*, only growths of minor size are successfully treated by electrolysis, those of major size being only partially removed; *g*, large growths, especially those with a wide base, should be attacked with double needles at base and single needle at apex; *h*, perforation and sloughing will result from the use of too much current, or from a prolonged use of a moderate one (see case No. 7); *i*, all cases should be thoroughly cocainised by placing a pledget of cotton saturated with a 10 per cent. solution of hydrochl. cocain over the part to be operated on, and leaving it there for 8 minutes.

* *Journal* on the American Medical Association, Nov. 10th, 1894.
† American Laryngological Association, Rochester, 1895.

HOW TO USE A VOLTMETER AS AN AMMETER.‡

‡ New York *Electrical World*.

By GEORGE T. HANCHETT.

It sometimes happens that in testing a dynamo or motor, or in other work around a railway power station, an accurate ammeter is very desirable. Sometimes switchboard instruments can be pressed into service, but often they are not sufficiently accurate, of limited range, or else they are too urgently required for their present service. In such a case some makeshift like the following may be very desirable, if not imperatively necessary for the work in hand.

If the terminals of a voltmeter are connected with the two ends of a resistance through which a steady current is flowing, a defection will be obtained which in numerical value is directly proportional to the current flowing in the resistance, and which only needs a multiplying factor to give the value of this current. This principle is utilised in the manufacture of almost every familiar type of direct current ammeter, and it is entirely feasible to apply it to other cases than in the manufacture of these instruments. For ordinary cases where small errors are admissible, the multiplying factor is merely the reciprocal of the resistance. If we connect a voltmeter, as in fig. 1, to the terminals of a resistance, the series coil of a dynamo, for example, the current flowing is equal to the potential indicated by the voltmeter divided by the resistance of the series coil, in accordance with Ohm's law. This assumes that the current taken by the voltmeter is a negligible amount, and with a good instrument its resistance is so great that even when its needle is fully deflected this may be assumed to be the case. It will at once be seen that it is necessary to know the resistance of the coil in order that the calculation may be complete. If the measurements are not to be strictly accurate and the conditions will not be objectionably affected, a length of wire of known gauge may be inserted and used as the resistance. The numerical resistance of the wire is then only a matter of a few minutes' calculation with the aid of a wire cable, which every electrician employed on such work should carry. It may be the case that an ammeter is at hand, but of too limited range to measure the output required. It will then be an easy matter to reduce the current to the limits of the instrument, and by taking a deflection at the terminals of the series-coil or other resistance it is proposed to measure with the aid of a voltmeter the value in ohms may be determined by dividing the voltmeter reading by that of the ammeter.

In any event the voltmeter may be connected aronnd the resistance and its readings recorded and the resistance measured at leisure, or when accurate instruments are available. The initial readings of the voltmeter may then be readily translated.

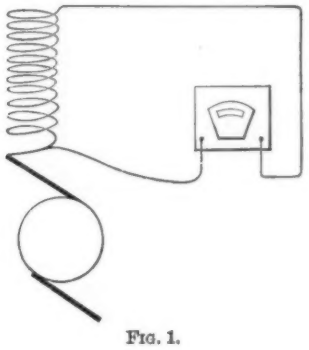

Fig. 1.

It is important that the resistance, if it be an inserted one, be of sufficient carrying capacity to carry the current without overheating.

The scale of the voltmeter should be as low as possible. The reason for this lies in the fact that low resistances are most readily available as a usual thing, and the volt's drop through them is very small, and therefore can be measured accurately only by a low-reading voltmeter.

In railway power stations the portable voltmeter at hand is usually of 500 volts scale, but often has a 5-volt scale for use in calibrating. This 5-volt scale is eminently suited for such measurements as those just described. In case the voltmeter has no low reading scale, one may be provided at the expense of a little calculation, a little labour, and a few cents expenditure.

Most voltmeters consist of a sensitive mechanism in series with a large resistance, as shown in fig. 2. A few volts, or often a fraction of a volt, applied to the terminals of the mechanism alone would deflect it clear across the scale. The larger portion of the voltage applied to the terminals of a voltmeter is used in forcing the current through this enormous dead resistance in its construction. A mere fraction of the total voltage suffices to force the deflecting current through the mechanism. Therefore, to obtain a low reading instrument, open the voltmeter and attach a light wire to the circuit, as shown, and bring it out to a neat binding post on the casing of the instrument, as shown by the dotted line. Some voltmeters have their resistances connected as in fig. 3, and in that case two auxiliary wires will be necessary as shown. In the first case, 2 and 3 will be the terminals of the low reading voltmeter. In the second case, binding

posts 3 and 4 would be used. It must be borne in mind that by attaching these terminals to any voltage greater than that which will deflect the needle fully across the scale the coil will be burned out. It is therefore necessary to proceed very carefully in determining what this voltage may be. It is as yet an unknown quantity, and the pressure of an ordinary sal-ammoniac cell if applied to these terminals may ruin the instrument.

Having neatly made the connections as indicated, take the instrument to some good testing laboratory and accurately measure the resistance between the binding posts 2 and 3, or in the second case, 3 and 4. The total resistance of the voltmeter is usually given, especially in the better makes of instruments, but if it is not, this must also be measured. It will pay to make these measurements with extreme accuracy, for after their completion you will have increased the utility of your voltmeter fully 50 per cent.

The multiplying factor to give true volts is now to be calculated as follows :—Divide the resistance of the separated mechanism by the resistance of the voltmeter, and obtain a

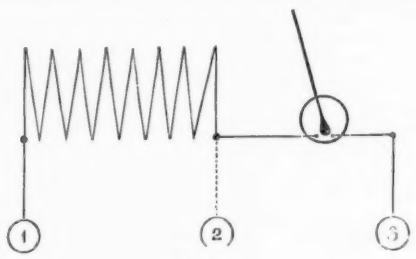

Fig. 2.

multiplier, which, when multiplied into the voltmeter reading, gives the true volts at the terminals of its separated mechanism.

Taking a practical example, suppose the resistance of the voltmeter to be 5,000 ohms, and the resistance of the mechanism to be 45 ohms, the multiplier would then be $\frac{45}{5000} = \cdot009$. Then if we connected the voltmeter by means of the circuit provided by the new binding posts, and obtained a deflection reading 550, the true volts at the terminals would be $550 \times \cdot009 = 4{\cdot}75$ volts. It is obvious that the factor ·01 would be much better for calculation purposes than ·009. If it is desired to obtain this, it can be done by unwinding a proper portion of the main resistance and connecting, as shown in fig. 3, provided that the resistance of the mechanism is less than $\frac{1}{100}$th of that of the entire instrument. This is a matter of some delicate manipulation, and it should not be attempted unless the operator is skilled. The factor obtained by direct connection is just as accurate, though less convenient. This change may be easily accomplished without breaking the seals which guard the mechanism.

The measurements which have been described thus far assume the voltmeter current to be negligible relatively to the

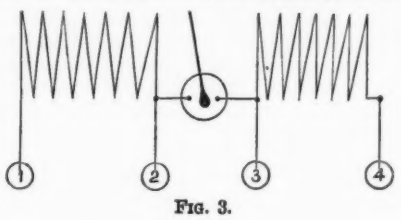

Fig. 3.

current measured, and as the maximum current of a good voltmeter is not more than $\frac{2}{10}$ths of an ampere, this is almost always the case in railway work. However, in the measurement of leakage currents, the calibration of instruments, or in electrical investigation, this factor cannot be neglected, and, therefore, this case is considered.

Assuming, as before, that we have a known resistance through which an unknown current is flowing, it is evident that if we connect the voltmeter to the terminals thereof, a portion of the current will be deflected through the voltmeter circuit, and the current through the main circuit which now divides through the voltmeter and the known resistance will be increased. If we consider that the known resistance and the voltmeter together constitute one instrument, we desire the value of the current feeding the two parts, and, therefore, the sum of the voltmeter and resistance currents. If R represents the value of the external resistance, and R the resistance of the low-reading voltmeter, then by the law of divided flow, the combined resistance would be

$$\frac{R\,R_1}{R + R_1}$$

As the voltmeter indicates the true voltage across the terminals of the combination, the current would be

$$C = \frac{(R + R_1)\,V}{R\,R_2} \qquad (1)$$

where V is the voltage at the terminals. By choosing the value of the resistance, R, fig. 1, we can make the voltmeter deflection as great or as little as we please, and by properly proportioning it, we can make the voltmeter read amperes directly without calculation, or by the use of an easy factor of transformation. It is very desirable to have this resistance as low as possible, and this to a certain extent limits our choice. As a good voltmeter should have a high resistance, so a good ammeter should have a low resistance, and we must not depart from these conditions in shunting our voltmeter for ammeter purposes. When we are using for a resistance some part of the actual circuit, this condition does not limit us; but when we insert a resistance in series for this purpose, it must be small, in order, first, not to disturb the initial conditions, and second, not to absorb too much energy.

Consider the case of a 500-volt instrument with a calibrating scale of 5 volts. Suppose that we wish to have the instrument read amperes directly on its 500-volt scale, using the 5-volt terminals in multiple with a resistance. What must this resistance be? Then our assumption demands that for every volt which the instrument indicates on its 5-volt scale 100 amperes shall pass through the system. We therefore have the condition that $100\,v = C$, and if the 5-volt coil of the voltmeter has a resistance of, say, 45 ohms, equation (1) becomes

$$100\,v = \frac{V\,(R + 45)}{45\,R}$$

Whence $$R = \frac{45}{4{,}499} = \cdot010002.$$

Had we neglected the resistance of the voltmeter we would have obtained R from simply

$$R = \frac{V}{C}$$

$$R = \frac{E}{1{,}002} = \cdot01 \text{ ohm},$$

and the difference is in this case negligible. Hence, for ordinary work with a voltmeter of sufficient resistance to be a commercial instrument, no allowance for its resistance is necessary.

The resistance of ·01 of an ohm is rather high for an ammeter, but were it used on circuits where dead resistance is inserted, *e.g.*, field circuits, this would not be an objection. Unfortunately, if we attempt to reduce the resistance of this instrument, the range is increased, and the disproportionality of the two is still maintained. The only possible way to correct this would be to employ a voltmeter with a lower scale. Good voltmeters do not need a large voltage to deflect the mechanism across the scale. In most cases the merest fraction of a volt will suffice. Therefore, when the instrument is provided with a special binding post as previously indicated, a very good ammeter, suitable for any purpose in its range, can be constructed by this method of shunting. However, when the mechanism alone is brought out to binding posts, the resulting scale requires an odd multiplying factor to get true volts, and this factor must be multiplied into the equation of condition as well. Suppose, for instance, in the case of this same voltmeter, that the factor is ·0007, *i.e.*, the voltmeter reading must be multiplied by ·0007 to get true volts. If we desire the scale to read directly the equation of condition would be

$$C = \frac{1}{\cdot0007}\,v = 1{,}428{\cdot}5\,V$$

and making this substitution, the procedure is the same as before.

It is sometimes necessary in laboratory practice to draw a very small current from a power circuit. This occasionally occurs in some railway testing, and to render this article more complete, the following method is given:—

In such a case, where the current is very small, and the voltage relatively high, an ammeter of high resistance is not only unobjectionable, but is a decided advantage, provided the working portion of the circuit is of low resistance. Suppose the case of a voltmeter, with a scale of 500 volts, and a resistance of 10,000 ohms. If this be connected in series with any device across the 500-volt mains, the current flowing is equal to the voltage indication divided by the resistance of the instrument. Such an instrument as the one described can be read directly within 5 volts, and by estimating to within ½ a volt. If, therefore, in this instance the reading was 475·5, the current would be ·04755 ampere, measuring the current with far more accuracy than any but the best mil-ammeters. The great resistance, which is often objectionable in such cases as these, is no hindrance.

Mr. A. O. Benecke writes as follows to the *Electrical World* regarding Mr. Hanchett's article:—

Allow me to make a few remarks in regard to the article "How to Use a Voltmeter as an Ammeter," by George T. Hanchett, printed in the *Electrical World* of April 25th.

As I have been obliged in the course of time to write, I may say, a hundred letters on the same subject, I believe it will be interesting to some of your readers to have their attention called to the fact that the best voltmeter is practically the worst for use as an ammeter. Theoretically, a perfect voltmeter should take no current. A good voltmeter therefore will take very little current. In every instrument based on the electro-magnetic action of the current, a certain number of ampere turns will be needed to balance a given controlling force. In an instrument having a permanent magnetic field these turns are wound on the movement, in an instrument of the soft-iron type they are wound on the field, and in an instrument based on the dynamometer principle they are wound on field and movement.

In order to obtain for a voltmeter the needed ampere turns with a minimum current, the number of turns has to be made as large as possible. As, however, these turns must be wound in a given space, the wire is necessarily a small diameter. Let us say, for example, a certain instrument requires one ampere turn for a full scale deflection. If we wind it with one turn only it will require 1 ampere. If we wind it with 100 turns it will require ·01 ampere. These 100 turns, roughly speaking, will have 100 times the length of the one turn, and as they have to be wound in the same space we have to reduce the cross section of the conductor to $\frac{1}{100}$th that of the one turn. In reducing the current from 1 ampere to ·01, we have therefore increased the resistance 10,000 times. It hence will require 100 times the E.M.F. to send a current of ·01 ampere through the 100 turns that it would require to send a current of 1 ampere through the one turn.

Under the three different types of instruments mentioned above, the one with a permanent magnetic field requires for a given controlling force the smallest number of ampere turns, as the current has not to build up the field as in the two other types. In the Weston voltmeter the permanent field is as strong as possible, the weight of the moving parts as light as possible, and therefore the controlling force can be a minimum. These instruments require for a full scale deflection ·63 ampere turn, which is made up by 63 turns on the movement with a current of ·01 ampere. As these 63 turns have a resistance of 63 ohms, the instrument requires, without any serious resistance, a difference of potential of ·63 volt between the binding posts. This, however, we must consider too high a potential difference for the use of the instrument as a shunt ammeter. If we build the shunt out of a copper wire dimensioned on the basis of one square inch per 1,000 amperes this wire would have to be about 80·7 feet long.

If we use the 5-volt scale of a 500-volt instrument in connection with a shunt for measuring current, which is designated as "eminently suited for such measurements" by Mr. Hanchett, our shunt would be about 641 feet long, and would have to consist of No. 00 B. and S. wire for 100 amperes, weighing about 256 lbs.

Besides this mechanical objection, there would be a very serious electrical one, viz., in measuring the current of a 500-volt generator with this device 1 per cent. of the total energy generated would be consumed by the measuring instrument.

The statement of Mr. Hanchett that the shunt principle is utilised in the manufacture of almost every familiar type of direct-current ammeter is not quite correct, as all the instruments of the soft iron type are not shunted. But in every case of a shunt ammeter the designer makes up the needed ampere-turns by employing as small a number of turns as possible and as large a current as practicable in order to keep the required potential difference down and to reduce the length of the shunt and the amount of energy lost in the instrument.

ELECTRIC TRAMWAYS FOR BERLIN.

In our issue of May 15th, reference was made to a proposal for the construction of a comprehensive network of electric tramways in Berlin. We now learn that Dr. Kallmann discussed this particular question at the last meeting of the Elektrotechnical Society of Berlin. His paper on this subject, which does not appear to have been published as yet, is dealt with editorially in the issue of May 14th of the *Elektrotechnische Zeitschrift*, from which the following is abstracted.

A glance at the map of Berlin at once shows that the operation of a power station could not be economically carried out in the manner usually adopted in smaller towns. The difficulty does not lie so much in the large extent of the town (about 10 kilometres from east to west and about 9 kilometres from north to south), as in the enormous power which would be required for the operation of so many cars. So far as distance is concerned, a power station situated in the centre of the city could very well supply current to all the lines, although the existing lines would require very large feeders, about 5 kilometres in length. But the station would assume gigantic dimensions. According to Dr. Kallmann's statement, about 33,000,000 car kilometres are annually run on the existing horse lines. If operated electrically, this would correspond to a work of 17,000,000 kilowatt hours. As, however, with the conversion of lines to the electric system the mileage run more or less increases, a consumption of 25,000,000 kilowatt hours would annually take place, without taking into consideration the subsequent growth of the town. This is equivalent to a mean output from the power station of practically 4,000 kilowatts. The maximum performance would naturally be considerably greater as the requirements of the lines are very different at different periods of the day. At Philadelphia, where there is both a day and night service, the maximum consumption of current is 53 per cent. higher than the average demand for current. As, however, night service would only be necessary on a small scale in Berlin, the percentage must be assumed to be greater, say, 60 per cent.; thus the maximum performance of the power station would correspond to 6,500 kilowatts, which, with the addition of the necessary reserve plant, would bring the total up to 12,000 H.P.

The erection of a large power station of this kind in the centre of the town would not be very convenient, and would not offer the same degree of working safety as several small stations erected in different parts of the town. The method in which the working of all the tramways in Boston is effected from four central stations, has already been explained by Dr. Kallmann. In this direction the development of electric lines is principally in view, since the distribution of current would be effected from the existing lighting stations. A beginning has already been made with the Mauerstrasse station, which supplies the three lines leading to the Exhibition, and Dr. Kallmann seems also to premise the consolidation of the other stations, or, at any rate, a centralisation of the current production for the working of the remaining lines. Whether the combination of the lighting and the power work is the best solution of the traffic problem for Berlin cannot at present be regarded as demonstrated. In smaller towns and even in Hamburg this system has proved entirely satisfactory. The cost of current in Hamburg has thereby been reduced to 7 pfennig per kilowatt hour, and a further diminution is expected.

That it is advantageous for a lighting station to supply current to a tramway is equally as valuable for Berlin as for any other town; but the question is, whether the tramway derives any advantage from taking its supply of current from the lighting station. If the tramway only requires a few hundred horse-power, this question may, in the majority of cases, be answered in the affirmative. But in Berlin the question is one of 10,000 H.P. or more, and for such a power separate production of current will probably afford important advantages. It is not, of course, necessary that the power station should be situated in the town itself; it would suffice to erect sub-stations in various parts of the town which would be supplied with power from a large central station situated in the outskirts of the town. That such a station would be able to produce current cheaply enough for the operation of the tramways is shown by the tariff of the Oberspree electricity works. The current is furnished to private consumers at 5 pfennig per kilowatt hour; the cost of production must therefore be less than 5 pfennig, and if a loss of 15 per cent. is assumed for conversion, the tramway current, including the redemption for the sub-stations, would only cost about 6 pfennig per kilowatt hour, or less than in Hamburg.

In his paper Dr. Kallmann referred to the conversion of the horse lines into electric tramways; the estimated expenditure being given at 23,500,000 marks (£1,175,000), without including the cost of the central stations and the feeder cable network. The saving effected by electric working is given at 6½ pfennig per car kilometre.

With an annual service of 33,000,000 car kilometres, this means in round figures 2,225,000 marks, a sum which is possible after providing for depreciation and interest on capital expenditure. Practically 90 per cent. of the lines can be carried out on the overhead system, leaving the remainder to some other method. On the latter lines there would have to be employed either an underground system or accumulator working with electric locomotives, as in Chicago, or on the so-called mixed system, as introduced at Hanover. This would only increase the cost by about 2 pfennig per car kilometre, and would not essentially diminish the economy of the whole installation.

LE RADIAZIONE DI RÖNTGEN CON TUBI DI HITTORF AD IDROGENO RAREFATTO.*

By RICCARDO ARNO.

The following communication is an extract from the *Transactions* of the Royal Academy of Sciences, of Turin.

It is known that the Röntgen radiation emanating from a Hittorf tube varies with the variation of the conditions in which is produced the cathodic radiation in the interior of the tube, and it is, besides, known that the more favourable conditions occur after some hours working of the said tube.

Setting out from the hypothesis proposed by several experimentalists that the cause of this fact has to be ascribed to an absorption of the gas inclosed in the tube on the part of the metallic electrodes during the discharge, I have undertaken to experiment upon a Hittorf tube with electrodes of platinum always filled with hydrogen gas before being submitted to the operations of rarefication and exsiccation. In such a tube, the absorption being brought to its maximum on account of the metal of which the electrodes are formed, it should happen, if in fact the intensity of the Röntgen rays are a function of the rarefication of the gas, that the conditions most favourable may be united in a very brief time relatively to that which occurs by the activation of the ordinary tubes.

If we admit the theory of Crookes, according to which the cathodic radiation is a projection of electrised matter thrown from the cathode upon the wall of the tube, it results that the intensity of the Röntgen radiation depends, beside on the degree of rarefication, also on the nature of the gas inclosed in the tube.

Continuing to base our reasoning on the hypothesis of Crookes, and, on the considerations of Lodge, we may observe that the velocity of the cathodic rays is, for a given degree of rarefication of gas contained in the generator tube, inversely proportional to the electrochemical equivalent of the same gas. Then experimenting with a rarefied gas, the electro-chemical equivalent of which is less than that of the air, *e.g.*, hydrogen gas, it must not obtain the velocity of the cathodic rays, and thence an intensity of the Röntgen rays greater than that of air, and this in correspondence to the same degree of rarefication.

ANNUAL EXHIBITION OF THE FRENCH PHYSICAL SOCIETY.

The annual exhibition of the French Physical Society took place on the 7th and 8th inst. at the hall of the Société d'Encouragement. In the department that specially interests us, we found nothing particularly novel. We will, however, mention the new measuring instruments brought out by the firm of Arnoux & Chauvin, and amongst others some violet ink registering instruments, some aperiodic voltmeters and amperemeters of varying sensitiveness, some ohmmeter-voltmeters for central stations, a portable galvanometer, some milli-amperemeters, a portable case with reducing mirror galvanometer for the measurement of electromotive forces from 0 to 300 volts, of currents of 0 to 300 amperes, and of resistances comprised between 10 megohms and ·00001 ohms. Messrs. Blondel and Labour show us a new universal wattmeter, the coils of which may be changed at will, and all parts of which are carefully insulated. M. Bullier exhibits an enormous block of carburet of calcium. M. E. H. Cadiot exhibits a model of an electrical hand borer and various little models of dynamos, gas and petroleum engines, &c. The old Cail establishments have constructed a Cail-Helmer dynamo of ·2 of an ampere at 3,000 volts. M. Doignon sends some little electromotors of very low power (10 to 150 watts). M.M. Ducretet and Lejeune exhibit, in the electrical line, a portable battery of 78 elements for long duration, giving 120 volts, and a Grassot meter, model 1896. Messrs. Gaiffe & Co show a condenser on the D'Arsonval system for high frequencies, a D'Arsonval aperiodic amperemeter and voltmeter, and also a medical alternating current transformer. M. Guerre works a series of tuning forks by electricity, and also various bells, and a sonometer. The Saint-Gobain factory shows various specimens of cylindrical glass troughs 1 metre high, and various models of troughs for accumulators, and also glass insulators. M. Rechniewski sent a 4-pole continuous current dynamo of 44 kilowatts, constructed for the Hotel de Ville. M. Richard shows some thermometers with electrical transmission to a distance, a registering voltmeter for two régimes, 3 and 150 volts, and a new music register, writing down notes, with their value and duration. The Cance Joint Stock Company shows types of Cance projector lamps of 6 to 8 amperes, and of 10 to 15 amperes, a series of bipolar interrupters acting suddenly with four contacts of 10 to 800 amperes, and also variable rheostats with a runner having a helicoidal movement for laboratory experiments, and for the excitation of dynamos.

Of course, we find the X rays in the exhibition, and various apparatus connected with them. M. Chebaud exhibited M. Hurmuzescu's electroscope, enabling the Röntgen rays to be studied, and another electroscope by the same inventor for studying the influence of the Röntgen rays of bodies of different natures placed in different media. The firm of Ducretet and Lejeune has also constructed a complete apparatus for carrying out experiments with the X rays, and, amongst other things, a frame with an aluminium plate. The firm of Pellin exhibited photographs obtained with the X rays, and also a photometer for these new rays. Acetylene gas was also exhibited in a series of new apparatus constructed by M. Trouvé, Messrs. Ducretet and Lejeune, and the Société Centrale des Produits Chimiques.

REVIEWS.

Current from the Main. By W. S. Hedley, M.D. London: H. K. Lewis, 136, Gower Street.

This little book deals with the application of electric lighting currents to electro-therapeutical purposes. It would appear, at first sight, to be a simple matter to make use of current from the main for medical purposes, and it would undoubtedly be much more convenient than using batteries or small independent installations. But Dr. Hedley shows that there are great risks attending the use of the comparatively high tension currents supplied by central stations when they are applied to the human body. Even 100 volts E.M.F. would produce a dangerous current if applied direct to a patient in an electric bath, and consequently a resistance must be interposed to reduce the current to a safe amount. If this bath be not insulated, when a leak occurs in one of the main leads, the maximum current may pass through the body of the patient to earth. The remedy for this, as Dr. Hedley points out, is insulation of the bath.

In the case of alternating currents, a transformer is used to bring the current to the required potential, and here, again, a breakdown of the insulation may be attended with the most serious consequences. Transformers like the "Woakes" or the "Miller and Woods" are recommended. These are very substantially built, and have their secondaries wound to give different voltages as required for the various medical applications.

The dangers that attend the application of current direct from the main would lead one to think that the safest course would be to use accumulators. The trouble of recharging and extra cost are no doubt serious objections, but we think that their advantages would outweigh these objections. One great advantage would be their low resistance. The existence of high resistance in the electro-medical circuit has been found to produce a much more painful effect on the patient. The reason for this has given rise to much discussion. Dr. Hedley criticises the views of his predecessors on this question, but we do not think he is at all more fortunate in his own explanation.

That Dr. Hedley is somewhat at sea in his views of the theory of varying currents the following quotation will show: "I hold that there is a difference between applying say 10 ma. at 100 volts, through a resistance placed in series with a patient, and applying 10 ma. with only just sufficient electromotive force to overcome the resistance of the patient's body. . . . . The reasons are as follows: (1) That at any break in the circuit the full voltage of supply is obtained, and (2) that upon completing circuit there is a much reduced electromotive force across that portion of the circuit which was previously broken; therefore it follows that between the moment of completing the circuit and the establishment of steady value of electromotive force there must have been a time rate of change, since no work can be done instantaneously. . . . . On first closing the circuit there will be at that instant no current; following quickly, there is to be expected a current rush, *probably in excess of the normal, and this rush would probably steady itself (together with the electromotive force) by oscillations of short period.*"

Dr. Hedley talks as if the behaviour of varying electric currents was as uncertain and erratic as that of politicians,

* Röntgen's Radiation with Hittorf Tubes for Rarefied Hydrogen. Torino: Carlo Clausen, 1896.

instead of being, as it is, as fixed and determinate as that of a stone falling under the action of the law of gravitation. When a circuit having a coefficient of self-induction L, and a resistance R is suddenly subjected to a voltage E, the current C at any instant is expressed by the formula $C = \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$.

From this formula it is easy to see that, theoretically, the current never reaches the steady value, so that "a current rush, probably in excess of the normal," is out of the question. It can also be deduced from this formula that the real difference between using a high E.M.F. with a resistance in series, and using an E.M.F. so low that it requires no additional resistance to be interposed, is that, in the former case, the rate at which the current increases is more rapid. Now it is an admitted fact that the more rapidly a current varies, the more painful are its effects on the body, so that we have here very probably the complete explanation of the more powerful effect of high tension with resistance on the body. The moral of this, for electro-medical practitioners, is to keep the resistance of the electro-medical circuit as low as possible, and its self-induction as high as possible, whereby sudden variations in the current will be prevented.

Dr. Hedley's little work contains many useful practical hints for the application of current from the main to medical purposes, and considering that the subject is in its infancy, and that the required combination of accomplished electrician and physician is, as yet, rare, we must take it that Dr. Hedley has made a useful addition to the literature of this subject.

The Year Book of Photography and Amateur's Holiday Guide, 1896. Illustrated. London: The Photographic News, 22, Furnival Street, E.C. Price 1s.

This excellent production is divided into five sections, the first dealing with progress and practice; the second with facts and formulæ; the third the amateur's holiday guide, which contains much information of interest to many others besides those interested in the practice of the photographic art; the fourth with lanterns and their accessories; and the fifth with novelties of the year in both photographic lantern appliances, and also in miscellaneous novelties. There is much that is of interest in this volume, which makes it of considerable value to both professional and amateur photographers and others.

The Process Year-Book, 1896. Illustrated. London: Penrose & Co., 8A, Upper Baker Street, W.C.

This is a beautifully printed and splendidly illustrated book, showing the various methods of process engraving used at the present time. The articles descriptive of the many processes of photo-engraving are very numerous, and towards the close of the work there occur "Hints on the Management of Arc Lamps" by Mr. A. Chester, mainly illustrated by reference to the Harp arc lamp. "Hints and Wrinkles," and the bibliography of process work bring to a close a book which all interested in process engraving should see and read.

CORRESPONDENCE.

"Seven Days' Hard Labour."

I happen to be reading my REVIEW backwards to-day by way of a change, and, consequently, first come upon your note headed "Seven Days' Hard Labour," in which you very properly slate certain persons for offences against the understanding. But I afterwards come to an article signed by "An Amazonian Faraday," in which it is stated that an order to "port helm" in this country means that the ship's nose is to go to port, at least that is the only way I can read it. The exact opposite is the case however. I am going to steer in a yacht race on Monday so hope your correspondent's paragraph won't exert any baleful influence over me, and only write to give notice that you will be held responsible for any such disaster as loss of race, collision, grounding, &c.

R. G. T.

May 23rd, 1896.

The Great Horseless Carriage Co.

Mr. Desmond G. FitzGerald has sent us for publication the following copy of a letter addressed by him to the Great Horseless Carriage Co.:—

[COPY.]

"94, Loughboro' Road, S.W., *May 23rd*, 1896.

"Charles Osborn, Esq.,

"Secretary the Great Horseless Carriage Co., Ltd.

"Sir,—In the list of patents, &c., referred to in your prospectus, I notice No. 1,054^{-96}, granted to myself and Mr. W. C. Bersey. As the inventor of the 'afluidic' system of mounting accumulators, to which this patent refers, and also as the owner of two-thirds of the patent itself, I should like to know how the latter came to be inserted in your list without my knowledge or consent.

"I fear that due care has not been exercised in the revision of the list of patents in question, for I notice one for the old and well-known invention in accumulators of Mons. Paul Gadot; this patent is, on the face of it, invalid.

"I am, Sir, your obedient servant,

"Desmond G. FitzGerald."

Dynamos for Electrolytic Work.

I have just completed a new design of machine to get over the faults mentioned in the letter of "Enquirer" in your issue of May 22nd, and I should be pleased to show it him working. This machine has other advantages for his purpose besides non-sparking.

W. Mackie.

London v. Paris Municipal Council.

If it be necessary for the London County Council, in its deliberations on the proposals made by a syndicate for the conversion of the tramways in the metropolis to a system of electric traction, to receive an object lesson in this branch of locomotion, it would only be necessary for the members of the Highways Committee to shortly pay a visit to Paris in order to investigate what the Municipal Council of the capital of France has thought fit to sanction for the benefit of the public. It is scarcely necessary to bring to recollection the fact that in and around Paris are already in operation tramcars worked by steam power, by compressed air, and by electricity on the accumulator system; but the latest method takes the form of an underground closed conduit system of tramway traction on the Vuilleumier and Claret principle, which was demonstrated experimentally with success at the Lyons Exhibition in 1894.

The new electric tramway, which is some 2½ miles in length, commences in the centre of Paris at the Place de la Republique, and terminates at Romainville, just outside the fortifications. The system, briefly described, consists in the transmission of electrical energy from the generating station at Lilas by means of an underground cable to a series of distributing boxes, arranged at intervals of 100 metres. These distributors are connected by means of wires to metallic plates, placed between the tramrails at distances of about 8 feet apart; and when the tramcar passes over these plates, the current is collected from the latter by means of brushes, which convey the current to the electric motors, the return being formed by the rails. Only the plates over which the cars are at any time travelling are "alive." This is in substance the system which the Paris Municipal Council have authorised, and the 20 cars to perform the service are on the point of being set in operation, and for which a concession has been granted until 1910, with the possibility, in case of extensions being carried out, of the powers being prolonged until 1930.

I have referred to this particular case not for the purpose of suggesting that this is the system most suitable for London, but rather in order to show that the leading local authority in Paris recognises the suitability of electric traction, on an underground system, for a great city, and is prepared to afford facilities to the promoters, and exceptional travelling opportunities to the public. In fact, the opening of this line will save at least one hour in time, as compared with the present means of journeying from Paris to Romainville. Whether the London County Council will be more favour-

ably disposed to the proposals of the London syndicate, at the meeting to be held about the middle of June, remains to be seen, although it is understood that the Highways Committee now propose to recommend the granting of permission to make experiments with the proposed conduit system. However that may be, I have considered it but right to point out the attitude of the Paris Municipal Council towards electric traction, in the hope that the London County Council may be led to follow the example set by Paris, and consent to the introduction of some improved system for the metropolitan tramways.

Cosmopolitan.

[In our leading pages, which were written before the receipt of this letter, we have suggested that our correspondence columns are open for argument *pro* and *con* on a very vital question for London, and this unexpected, but welcome, communication comes to hand at an opportune moment.—EDS. ELEC. REV.]

BUSINESS NOTICES, &c.

Electrical Wares Exported.

WEEK ENDING MAY 26TH, 1895.	£	s.
Algoa Bay	30	0
„ „ Teleg. mtl.	187	0
Amsterdam	84	0
Bangkok	45	0
Bombay	126	0
Bremen	25	0
„ Teleg. mtl. ...	245	0
Brisbane	28	0
Brussels...	782	0
Buenos Ayres	239	0
„ „ Teleph. mtl.	1,440	0
Calcutta	86	0
Cape Town	375	0
Christiana. Teleg. wire	61	0
East London	1,112	0
Flushing	10	0
Gandia	1,000	0
Gothenburg. Teleg. wire	95	0
Halifax. Teleg. mtl.	800	0
Hiogo	73	0
Hong Kong	187	0
Launceston	590	0
Marseilles	400	0
Mauritius	23	0
Melbourne	586	0
Monte Video	16	0
Ostend	14	0
Penang	22	0
Port Natal	2,400	0
Rockhampton	200	0
Rosario. Teleg. instms.	344	0
Shanghai	22	0
Sydney. Teleg. mtl. ...	925	0
Wellington	231	0
Total	£12,803	0

WEEK ENDING MAY 26TH, 1896.	£	s.
Albany. Teleg. material,	1,310	0
Amsterdam	80	0
Bombay	171	0
„ Teleg. matl.	42	0
Boulogne	33	0
Bremen	10	0
Callao. Teleg. cable ...	1,033	0
Calcutta	92	0
Canada	15	0
Cape Town	39	0
Colombo. Telephone ...	25	0
Delagoa Bay. Teleg. matl.	66	0
Durban	30	0
East London	413	0
Flushing	32	0
Hong Kong. Telep. stores	39	0
Launceston	75	0
Labuan	17	0
Malta. Teleg. appa. ...	62	0
Melbourne. Teleg. appa.	27	0
Montreal	30	0
Odessa	29	0
„ Teleg. matl....	436	0
Port Elizabeth	31	0
Port Said	7	0
Rangoon...	34	0
Rio Janeiro. Teleg. matl.	5,285	0
Rockhampton	80	0
St. Petersburg	93	0
Shanghai	22	0
„ Teleg. matl.	9,434	0
Singapore	267	0
Stockholm. Teleg. matl.	164	0
Sydney	123	0
Valparaiso. Teleg. matl.	1,010	0
Wellington	216	0
Yokohama	221	0
Zanzibar. Teleg. matl.	60	0
Total	£21,153	0

Change of Address.—Messrs. Eugen Conrady & Co., electrical and mechanical engineers, announce that they have removed from Keighley to London, where they will continue to manufacture their specialities at their new works, situate at 35, Charles Street, Hatton Garden, E.C.

County of London and Brush Provincial Electric Lighting Company, Limited v. the Vestry of St. Leonard, Shoreditch.—This was an action commenced by the County of London and Brush Provincial Electric Lighting Company, Limited, to restrain the Vestry of St. Leonard, Shoreditch, from laying down electric lines beyond the area within which the Vestry are authorised to supply energy under the Shoreditch Electric Lighting Order, 1892. It appeared from an affidavit that the Vestry commenced on May 21st to excavate a trench for the purpose of laying down electric lines within the parish of St. Luke, Middlesex, a district for which the County of London Company have a provisional order. On the application of Lord Robert Cecil (instructed by Mr. Sydney Morse), Mr. Justice Henn Collins, on the 21st inst., gave the company leave to serve summons with writ for June 2nd, and granted an injunction in the meantime.

Price List.—We have received from the General Electric Company, Limited, a revised trade list of flexible cords. Particulars, prices, &c., are given, in tabulated form, of cords with pure and vulcanised rubber insulation.

Cable Making Machinery.—Messrs. Johnson & Phillips, who hope shortly to publish their promised enlarged catalogue of cable making and wire covering machinery, have issued an illustrated sheet giving engravings of a few of the machines which they have manufactured since the first catalogue was published. This sheet shows about 20 different kinds, including yarn serving, automatic coiling, combined cabling and serving, triple tandem and other stranding machines, steam jacketed compound tanks, rubber and cotton covering machines, tape cutting lathes, wire twisting machines, drums and stands, measuring and polishing machines, 3-headed longitudinal rubber covering plant, automatic wire winding machines and swifts. The automatic coiling and the combined cabling and serving machine were made for H.M. Postal Telegraph Factory for dealing with large quantities of telephone and other wires.

Electric Launches.—"Electric Launches on the Thames, 1896," is the title of a neat booklet, which has been issued by the Immisch Electric Launch Company, Limited. There are a few photographs of launches, and complete particulars of the various trips that may be taken, with details of the chief places of interest between Oxford and Richmond, also maps, railway time tables, &c. The company lets out launches and the costs per day are stated. Tom Tagg, who has been interviewed by an evening paper, asserts that the electric launch business is on the decline. We thought it had barely commenced, but the "jolly young waterman" is an authority.

Liquidation Notice.—At meetings of the London Refuse Steam Generator and Electrical Power Corporation, Limited, held in London on March 30th and April 14th, a special resolution was passed winding up voluntarily, Mr. C. W. Grimwade of 38, Coleman Street, E.C., being appointed liquidator.

New Business.—Mr. G. A. Steinthal has opened an establishment for electrical contracts and supplies at 7, Brazennose Street, Manchester, the management of which has been entrusted to Mr. W. P. Steinthal, B.Sc.

Peache's Engines at the Indian Exhibition.—The reopening of the Empire of India Exhibition at Earl's Court leads us to remind our readers of an exhaustive description of Peache's patent high speed single-acting engine which appeared in our issue of October 25th, 1895. Prof. A. B. W. Kennedy has made a very careful trial of one of these engines at the works of Messrs. Davey, Paxman & Co., of Colchester, the makers of the engines, and concludes his report with the statement that for an engine of the size tested and working non-condensing, the working of the engine (it had been running continuously for nearly 12 hours), was satisfactory from beginning to end. There are two three-crank engines, each coupled direct to a 100 kw. Mordey alternator, developing 220 H.P. each at 355 revolutions, and one two-crank engine coupled to a 75 kw. alternator developing 150 H.P. at the same speed.

Public Examination.—The *Glasgow Mail* says that Chas. Gordon Stewart, jun., electrician, of 11, Roseburn Place, Edinburgh, will be examined at the Edinburgh Sheriff Court House on June 8th, at 2 o'clock.

Reconstruction.—The *London Gazette* contains notice, signed by C. J. Wharton, Chairman, that at meetings of the British Thomson-Houston, Limited, held at 38, Parliament Street, S.W., on May 1st and 18th, resolutions were passed winding up the company voluntarily for the purposes of reconstruction, Mr. James Devonshire being appointed liquidator. The new company will be named the British Thomson-Houston Company, Limited. Agreements in respect of the reconstruction were approved.

From a correspondence which has appeared in the *Financial News* it appears that three-fifths of the capital of the British Thomson-Houston, Limited, has disappeared, and shareholders have been informed that they can have £40 for every £100 of their investment in cash or shares in the new company. A dividend of 2½ per cent. was paid last autumn, and one is naturally led to ask where this dividend came from if the business has been working at so great a loss. Mr. Ernest Devonshire, who signs himself as the liquidator of the old company, and the manager and secretary of the new concern (the *London Gazette* notice says Mr. *James* Devonshire), replying to the criticisms of a correspondent, says that the company unfortunately spent a large portion of its capital in experimental and pioneering work. He adds that electrical traction having made great strides in recent years, and public opinion in England having also awakened to its importance, some of the principal shareholders of the old British Thomson-Houston, Limited, suggested the advisability of putting the company on a proper footing to meet present and future requirements. These gentlemen were prepared to furnish further capital to a large amount, but they naturally objected to the prosperity of a new company being handicapped by the result of the unremunerative working of the pioneer company. Under these circumstances, the body of the shareholders was approached, and it was deemed advisable to reconstruct, 85 per cent. of the total share capital voting, and 85 per cent. of the total share capital confirming the arrangements made between the old company and the new, whilst adhesions to the extent of 3 per cent. were sent in too late for legal voting purposes.

The Universal Engine.—In consequence of the active demand for the Raworth Universal steam engine, which we recently described, the directors of the Brush Electrical Engineering Company have decided to make a large extension of their works at Loughborough. The new tool shop, which will be devoted entirely to the engine trade, is to be 160 feet long × 48 feet wide. Building operations have already commenced, and it is hoped that by this prompt action the imminent danger of delay in the execution of orders and consequent disappointment to customers may be averted.

The British Aluminium Company.—This company has purchased the ground in Ingleston Street, Greenock, formerly occupied by the engine works of Messrs. R. Steele & Co. It extends to about six acres, and has water-power from one of the falls.

ELECTRIC LIGHTING NOTES.

Ashton-on-Mersey.—The Altrincham Electric Supply Company's Bill, to supply electricity in the district of the Ashton-on-Mersey Urban District Council, and part of the Bucklow Rural District Council, has been ordered to be reported for second reading.

Australia.—The Perth correspondent of the *Financial News* says that Mr. Philip Hargan, the Coolgardie mining agent, has left for England to make definite arangements for the electric lighting of Kalgoorlie. Mr. Hargan has formed an English company to undertake the work.

Asylum Lighting.—The chairman of the Committee of Visitors of the Upton Lunatic Asylum, at the last Cheshire County Council meeting, moved that a grant of £3,000 be made for lighting the asylum buildings electrically. This was agreed to.

Bath.—The Council, on 22nd, met specially to pass a resolution applying to the Local Government Board for power to borrow £45,000, with which to acquire and improve the company's electric lighting works.

Bedford.—During the last two months applications have been received for about 550 additional 8-C P. lamps. The Bedford Electric Light Company are seeking a provisional order to supply electricity in the parishes of Great Berkhampstead and Northchurch.

Blackpool.—The Corporation have not yet obtained the sanction of the Local Government Board for borrowing £30,000 more for electricity extension, and it is understood a reply will not be received until an expert engineer employed by the Board has reported on the scheme. Mr. Jno. Hesketh is succeeded as engineer by Mr. Quinn, who has been the chief assistant electrical engineer to the Brighton Corporation. He commences with a salary of £300 a year, and Mr. Cooper, who has been at the electricity works for nearly two years, will be second in command at a salary of £130 a year.

Brighton.—The mains are to be laid down part of Grenville Place, Carlton Hill, and Eaton Place, at a cost of £265.

Cardiff.—The electric light mains are to be extended from the Infirmary to Clifton Street, and from Canton Bridge, through Cathedral Road, to Plasturton Place.

Chelmsford.—At a special private meeting of the Town Council on Thursday last week it was decided that the question of purchasing the town lighting from Messrs. Crompton and Co for £34,828—the price asked—should stand over for the present.

Chepping Wycombe.—The Town Clerk has filed a notice in the *London Gazette* to the effect that the Urban Sanitary Authority proposes to submit to the Board of Trade for approval a deed of transfer of the powers of the Corporation under the Electric Lighting Order, 1894, to the High Wycombe Electricity Supply Company, Limited. The company will pay £246, the costs incurred in procuring the order.

Colliery Lighting.—The Consett Iron Company, Limited, propose to instal the electric light in the workings and at the pitheads of their Hunter and Derwent collieries at Medomsley.

Edinburgh.—The Council has resolved to reduce the price per unit to 5d. for lighting and 3d. for motors, and the public lighting to £18 per lamp, meter rents to be abolished. The convener, in moving the resolution, said that they were for five and a-half months working at a loss, the turning point being about September 26th. From that point, to April 16th, they made their income for the year. They were now again working at a loss, so that making their report for 13 months was a disadvantage, having made a loss from April 11th to May 15th of about £200. The total income for the 13 months from private lighting is £13,220 18s., after allowing the discounts, and for this they sold about 550,000 units. The total charge was about £12,800, leaving a balance of about £4,204. The engineers estimate their income to May 15th, 1897, at £28,100 counted at present rates. and the total expenditure £21,122, leaving a balance of £6,978. The proposed reductions, however, would reduce the estimated income by about £4,100, but still leave an expected balance of £2,878.

Eston.—Dr. Townsend stated at the last District Council meeting that the tenders received for lighting the streets electrically showed that the cost would be about the same as for gas. The Council will discuss the matter in committee.

Folkestone.—The Corporation is stated to have adopted a report recommending the acceptance of the Hopkins contract to supply the town with electric light, subject to certain conditions.

Glasgow.—The deputation which visited Brighton, Portsmouth, and Blackpool, has issued its report, which recommends the use of overhanging lamps as adopted at Brighton, with certain modifications, and also that pending certain experiments, the whole question of the street lighting by electricity be referred back to the special sub-committee for further consideration.

Hastings.—At the Town Council special meeting on 22nd inst., the subject of the Council supplying its own current for street lighting was discussed at length. The borough engineer had advised the Corporation to undertake the street lighting themselves, and suggested a suitable site for a station, and stated what plant would be required for lighting the streets, the Town Hall, the Brassey Institute, and other Corporation buildings. The Corporation would have to purchase the lamps, standards, cables, pipes, and other street apparatus of the company, and this the engineer considers, added to the cost of the new station and plant, will amount to £7,560. The matter was subsequently referred to Mr. P. M. Grenville, electrical engineer, of Old Queen Street, London, who strongly endorses the borough engineer's proposals. It is estimated that by adopting this scheme, there will be an annual saving of £744, or ½d. in the £. The result of the discussion was that the Council agreed to put the scheme in hand, and apply for power to borrow the necessary money.

India.—The Municipal Committee of Lahore are considering the question of lighting the streets by electricity. A company is expected to take up the work.

Keswick.—The District Council's Electric Lighting Bill has been ordered to be reported for second reading.

Portsmouth.—Four arc lamps are to be placed in Pembroke Road, Portsmouth, between the Common and the High Street.

Rye.—The first electric light installation in this town has just been put into the premises of Messrs. W. H. Delves & Son, High Street, Mr. Sharpey having carried out the work.

Salford.—A Local Government Board inquiry was held on 20th inst. into the application of the Corporation for a loan of £5,000 for electric lighting, and other sums for other purposes.

Stafford.—The report of the Electricity Department for the five months actual working, says that so far everything had been exceedingly satisfactory. No hitch whatever had occurred anywhere, the number of consumers was increasing, and the accounts showed a net credit balance of £296 11s. 6d. This the Committee regarded as very encouraging, and recommended that the whole amount be carried forward to next year. "So far every indication pointed to the wisdom of the Corporation having control of both systems of lighting, and to their being under the care of one manager and one committee, by whom it was confidently hoped that each system, with its large financial obligations, might prove highly successful and beneficial to the town." Although there was a net credit balance of £296 11s. 6d., the actual profit was £54.

Swansea.—Mr. J. C. Howell explained his proposals, *re* the electric lighting order, to a company of gentlemen at the Albert Hall on 21st inst. He suggests that the Corporation have power to purchase the undertaking at the end of seven years, and says that if they allow him to erect overhead wires, he can make an arrangement with the tramway company to supply them with power, and could reduce the price of the public lighting by 30 per cent. In this way the town would be insured against loss.

Wrexham.—The Board of Trade having revoked the 1890 electric lighting order, the Lighting Committee is to consider what steps shall be taken to adopt an electric lighting installation.

York.—The representatives of the various parishes resolved, on 22nd inst., to call a mass meeting of ratepayers to discuss the electric lighting question.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Bristol.—At the fifth annual dinner of the Bristol Tramways and Carriage Company, Limited, on 21st inst., in acknowledging a toast, Mr. Challenger, the traffic manager, said the great success of the electric tramway had induced them to extend it to Eastville, which would shortly be done. The tramway to Ashton Gate would soon be made, and he hoped it would not be long before they had the electric cars at Clifton. The electric tramway had not led to a decrease of employment but an increase. The highest number of passengers they had carried during any previous year was 13,000,000, but he thought they would reach 18,000,000 this year.

The Whit Monday traffic on the electrical tramways was very heavy, the line being very popular with the public. Compared with Easter-time, when the same number of cars were running, the increase in passengers carried was 2,330.

Belfast.—The engineer has been authorised to attend the annual meeting of the Municipal Electrical Association in London on June 10th, 11th and 12th.

Brussels.—The Conseil Communal of Ixelles (Brussels) have been approached with a view to the granting of permission for the construction of three conduit electric lines. It has been decided in favour of the third line, which will be laid between the Gare du Midi and the Chaussée de Waterloo.

Calcutta.—We learn that the Calcutta Tramways Company have given up for the present their intention of introducing electric power, owing to the initial cost involved.

Electric Power at Barberton.—A few weeks ago we published letters which had appeared in the *Financial News* from Mr. W. B. Esson and Messrs. Easton, Anderson and Goolden, Limited, on this subject. A further communication now comes from Mr. H. J. S. Heather, A.M.I.C.E., electrical engineer in charge at Moodie's Electrical Works, Barberton. He says, regarding the statement that attempts to crush by electric power have been made at Moodie's Fortuna, "does it not appear strange that the United Ivy Reef, who have been dependent on power supplied from the same installation, have found it a success, and with it have been able to declare a dividend, though crushing ore of no greater value? The fact is that the power is a success; but it would appear that the management of the Fortuna mill has not been. As to the attempts to crush by means of the power, I have to point out that these attempts succeeded in using up all the available ore, and, cuttlefish like, the late manager of the Fortuna has attempted to obscure the real reason for having to shut down by condemning the power. With regard to the installation itself, I must admit that Moodie's Company have not for use as much power as could be obtained from the same source under a different system. It has been arranged to make the necessary modifications."

Leeds.—A daily contemporary says that an offer has been made to Leeds Corporation by Yorkshire House-to-House Electricity Company, to furnish power from its central electric light station for the operation of the proposed new electric tramway in that town.

Light Railway.—Steps are being taken for promoting the construction of a light railway from Corwen to Bettws-y-Coed, a distance of 25 miles, through a strictly agricultural district. The various railway companies in the district are to be approached, and failing their taking up the proposal, a local company will be formed.

New Mountain Railway.—Public subscriptions to the extent of 3,500,000 francs have just been invited for the Gornergratbahn, Aktiengesellschaft, Sitten. The object of the company is the construction of a rack railway, to be operated by electricity, on the Gornergrat, near Zermatt. The engineering and electrical plant will be supplied by Messrs. Brown, Boveri and Co., of Baden, in conjunction with two other firms.

North Staffordshire.—The North Staffordshire Tramways Company has applied for permission to use steam as a motive power for two years longer. The Corporation is of opinion the authority should be for only 12 months.

Paris.—The Paris Town Council, which has approved in principle of the construction of a narrow gauge metropolitan electric railway, has now placed on view at the Hotel de Ville preliminary plans of the railway for the inspection of the public up to June 18th. The scheme comprises four lines.

TELEGRAPH AND TELEPHONE NOTES.

International Telephonic Communication.—During the course of the present year, a second telephone line is to be erected between Vienna and Berlin, to which both the towns of Prague and Dresden will be connected.

London-Paris Cables.—A Reuter despatch, dated Paris, 22nd inst., says that M. Boucher, Minister of Posts and Telegraphs, after having previously arrived at an understanding with the British postal authorities in the matter, has just decided to establish four fresh telephone wires between Paris and London. This important step, which will tend to improve and develop telephonic communication between the two capitals, will be effected without cost to the French Exchequer, owing to the fact that the corporation of the Paris stockbrokers has undertaken to advance the sum of 650,000 fr., the cost of the aerial lines in French territory and half the cost of the cable across the Channel, the corporation to recoup itself out of the receipts. The telegraphic communication between the two countries will likewise be favourably affected by the laying of the four new telephone wires, which will be employed both for telephonic and telegraphic purposes.

New Cable.—The steamship *Silvertown* arrived off Bacton, on the Norfolk coast, early on Wednesday morning with the new cable to be laid between England and Germany. The shore end was beached, 20 horses being required to land it. The vessel then steamed away, paying out the cable as she went, in the direction of Germany.

Telegraphy without Wires.—The experiments made in this direction in England are about to be repeated in Denmark. In this connection, it is to be noted that the Danish naval officer, Sorensen, has devised a system whereby telegraphic communication without the use of connecting wires can be effected between the shore and ships at anchor. The Danish Government are about to make a trial of the system between the Thyborn lifeboat station and the mooring station of the *Vestkusten*, the installation to be set in operation in July next.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (1869, Anglo)	April 6th, 1895 ...	...
„ „ (P.Q.) ...	June 24th, 1895 ...	May 23rd, 1896.
Puerto Plata-Martinique ...	Dec. 19th, 1895 ...	...
Ceara-Maranham	April 28th, 1896 ...	...
San Thomé-Loanda	May 2nd, 1896 ...	May 21st, 1896.
Monte Alegre-Santarem ...	May 5th, 1896 ...	...
Landlines.		
Trans-Continental line beyond Mazal (Mashonaland) Telegrams for Tohikwawa and Blantyre cannot be accepted.	March 12th, 1896 ...	...
Bolinao-Manila—telegrams are sent by post	May 19th, 1896	...
Communication with Cartagena and Barranquilla, Columbia	May 22nd, 1896.	...
Broome—Perth, West Australia	May 24th, 1896.	...
Saigon—Bangkok	May 24th, 1896. ...	May 24th, 1896.

Telephone between London and Nice.—It is stated that two English engineers have made arrangements with the French Government for the establishment at an early date of telephonic communication between London and Nice.

The Pacific Cable Conference.—Sir Donald Smith, the High Commissioner for Canada, and Sir Mackenzie Bowell, the two delegates from Canada to the inter-Colonial conference on the subject of a cable to join Australia to England *via* Canada, with Mr. Sandford Fleming, an expert on such matters, visited the Colonial Office on Tuesday afternoon. The arrangements for the opening of the conference are not yet complete, but the first meeting to arrange the procedure of the inquiry will probably take place early next week, as the Australian delegates, Sir Saul Samuel and Mr. Duncan Gillies, will then be in town. It is doubtful if Mr. Chamberlain will be able to find all the time necessary to preside at the meetings. Mr. H. W. Mercer, one of Mr. Chamberlain's private secretaries, will act as secretary to the conference.

CONTRACTS OPEN AND CLOSED.

OPEN.

Austria.—June 1st. The municipal authorities of Prague are inviting tenders for the erection and equipment of a municipal electricity generating station in the town for electric lighting, power, and tramway traction purposes. Tenders are to be directed to the Stadrath der Haupt, Stadt Prague, Prague, Austria, from whom full particulars may be obtained.

Bradford.—June 2nd. From the Town Clerk (Mr. McGowen) particulars may be obtained of works required in connection with the electric light installation at the Cliffe Road Destructor Works, for the Corporation.

Cork.—June 3rd. Tenders are wanted for the necessary plant, machinery, &c., for electrically lighting the pumping station of the Corporation Waterworks, Lee Road, Cork. For further details, apply to Mr. D. F. Giltinan, secretary of committees, Municipal Buildings, Albert Quay, Cork.

Exeter.—June 3rd. The secretary (Mr. A. E. Boyce) of the Devon and Exeter Hospital invite tenders for the proposed installation of the electric light at the Hospital for the governors. Particulars from the architect, Mr. C. Cole, 50, High Street.

Glasgow.—June 15th. The Caledonian Railway Company requires tenders for stores for the twelve months commencing August 1st. The following are some of the items:—(2) Bolts and nuts; (18) copper rivets; (29) India-rubber; (33) iron rivets; (34) galvanised wire and wire fencing requisites; (49) screws; (50) shovels, spades, and graips; (52) spelter, tin, and lead; (59) sundries; (60) telegraph and electric appliances; (65) tinwork; (66) tools. Specifications, &c., may be obtained on and after June 1st from Mr. Jas. Lorimer, superintendent of stores, Caledonian Railway, Charles Street, St. Rollox, Glasgow.

Grimsby.—June 5th. The Urban Sanitary Authority is inviting tenders for the lighting of the public streets for one year. Particulars of the Borough Surveyor at the Town Hall.

Leeds.—June 20th. The Council require tenders for an electric installation for working on the overhead system a 7-mile (double track) length of tramways. A note of the seven sections, poles, conduits, wires, cars, accumulators, &c., will be found in our "Official Notices."

Leicester.—June 6th. Tenders are wanted for the supply of coal cobbles, or nuts, for one or two years ending 31st inst., for the Gas and Electric Lighting Committee. Particulars and form of tender can be obtained on application to Mr. Alfred Colson, M.I.C.E., engineer and manager.

Lima.—June 1st. The Municipal Council is inviting tenders for the establishment and working of the electric lighting in the squares and streets of the city, with power to work the private supply under a 20 years' contract. Particulars to be obtained at the Peruvian Legation, 13, Comeragh Road, West Kensington, W.

Mexico.—August 31st. The Municipal Council of Mexico is inviting tenders for the concession for the electric lighting of the public streets during a period of eight years.

Portugal.—June 3rd. The Royal Company of Portuguese Railways is inviting tenders for the supply of a quantity of "small telegraph material." Tenders to be sent to the Ingenieur Chef du Service des Magasins de la Compagnie Royale des Chemins de Fer Portugais Santa Afolonia, Lisbon. Particulars from office of company, 28, Rue de Chateaudun 28, Paris.

Roumania.—June 1st.—Tenders are being invited by the General Direction of the Roumanian Posts and Telegraphs in Bucharest for the supply of two tons of hydro-chlorate of ammonia and three tons of copper sulphate.

Saxony.—June 10th. The Saxon State Railway Telegraph Department at Dresden is inviting tenders until June 10th for the supply of 60 tons of galvanised iron wire, 12,000 porcelain insulators, and 8,500 zinc cylinders for batteries. Tenders to be sent to the Königliche Betnebs-Telegraphen-Ober-Inspection, Sächsische, Staatseisenbahnen, Friedrichstadt, Dresden.

CLOSED.

Brighton.—For the supply of armoured and unarmoured lead covered cables during the year ending May 1st, 1897, the tender of the Callender's Bitumen, Telegraph, &c., Company has been accepted at the following prices:—Unarmoured cable, size ·008, price per rink, £28; armoured cable, price per mile ·017 sq. inch cable, £74; price per mile ·05 and ·03 sq. inch concentric cable £242. The tender of Messrs. Skeats & Co., Brighton, for fitting up 450 street gas lanterns for incandescent electric lamps, in accordance with specification prepared, for the sum of £180, with a further price of 8s. for each additional lantern fitted up. A main is to be laid from Lewes Road as far as 126, Islingword Road, and the public lamps there are to be fitted with incandescent electric lamps.

Coventry.—The Electric Lighting Committee has given the contract for boilers, mechanical stokers, engine, alternator, fittings, &c., to Messrs. J. Fowler & Co., at £4,198.

Wakefield.—The City Council last week accepted the tender of Messrs. Holme & King for the bricklaying, excavating, carpentering and other work for the proposed electric lighting works, at £7,887 15s. 6d.; the contracts for plumbing, smiths', painting, and glazing work have gone to Mr. Mosley, Mr. Bailey, Messrs. C. Turner and Sons, and Mr. J. Scaife, respectively.

NOTES.

The Trunk Lines.—The Post Office takes over the working of the second portion of the trunk telephone lines acquired from the National Telephone Company on Saturday, 30th inst. The lines in question are those falling in that part of the country bounded roughly by the River Thames on the south, and by the rivers Severn and Dee on the west, by a line drawn from the Dee mouth to the Humber Estuary on the north, and on the east by the German Ocean. It comprises the South Midland, North Midland, and Eastern Engineering Districts of the Post Office Telegraphs. From Saturday midnight the trunk telephone work in these districts will be vested in the Post Office.

Sir David Salomons on Electric Road Carriages.—Our contemporary, *Commerce*, publishes this week an account of the interview between "Hermes" and Sir David Salomons. The chairman of the City of London Electric Lighting Company, Limited, says that if the fullest scope were given to electricity, it would be quite impracticable for road motors, except for quite short journeys, and in places where charging stations existed. The weight of any kind of storage battery is so great in proportion to the power developed, that in order to fit a road carriage with it for, say, a journey of 60 or 70 miles, would require an enormous affair, quite out of proportion to its possible utility. "So that electricity is practically out of it altogether for the present?" queried the messenger of the Gods. "Decidedly, for real work," was the reply.

The P.Q. Atlantic Cable.—The *Seine* has repaired the P.Q. cable in deep water, thus restoring communication through this system, which has been interrupted since June last. The *Seine* is now on her way home.

A New Electrical Carriage.—Last Saturday morning, we visited the Imperial Institute for the purpose of witnessing the trials of a new electrical carriage, the interesting feature of which was that primary batteries were employed. Rumour had cast beforehand a glamour over the event; it was said that each cell would give something like 17 volts, and that the Spanish Ambassador would honour the trials by his presence. After many fruitless wanderings up and down long corridors, we at last got scent of the electrical carriage. It was being mended when we came across it, and the Ambassadorial family was exercising patience under one of the covered ways. The inventor, M. Julien, is a Spaniard, and as our acquaintance with the Spanish language is confined to two words, and M. Julien does not understand English, we had to obtain our information from one of his assistants. First of all we were informed that it was only a mechanical defect that was being remedied, and while the repairs were being effected, we were told that the battery was destined to revolutionise the electrical world. And here we will trot out our Spanish; *Quien sabe?* We expressed no alarm, but asked the number of cells. "Ah! I cannot give you that; I have the whole of the information in my office, but until the patents are complete it is impossible to say anything. But you can take it from me that the battery is one of marvellous power. It can propel a carriage 20 miles an hour, and will last for 126 hours without recharging." By this time the carriage was repaired, and it was brought forth to make a Spanish holiday. The inventor mounted the box, and one turn of the handle was sufficient to send it racketing along the asphalte court. Then it turned the corner and stuck, but that was the fault of the corner, and not the apparatus. However, four strong men put it in the right way, and soon it was gaily zigzagging back again. Somebody made the remark that the inventor was a bad driver, and we accepted it. As the carriage passed the Ambassador, the driver bowed, and was nearly thrown from his seat. Although great care was exercised in going round the end of the gardens, it was obvious from the first that the carriage had taken a dislike to a seat, and eventually shied, and charged wildly into it. At this juncture a rivalry was set up by a Daimler motor car and an electrical carriage entering the gardens; this so unnerved the primary battery, that the carriage was backed into some more seats, and the inventor dismounted, and four men brought it back to shelter again.

Nikola Tesla.—Mr. Tesla, a few days ago, announced the discovery of a method of inducing millions of etheric vibrations per second within a vacuum tube without using any direct electrical connection. An ordinary 16-candle bulb gives by this method, it is said, a light equal to 250 candles, which is sufficient to light very pleasantly a large room. It enables rapid and perfect photographs to be taken. Its commercial efficiency is claimed to be three times as great as that of the prevailing system, and it provides an ample margin for further improvement. *Voilà tout.*

The Latest Test for Dynamos.—A correspondent writing to a contemporary, states that a dynamo specification which reached him on the 20th inst. contained the following clause:—Test. "A run of six hours at full load will be made to test the efficiency of the machine, which, *after one minute's electrification*, must not have increased in temperature, &c."

Foreign Competition.—An article on "British Apathy and German Energy," in Wednesday's *Pall Mall Gazette*, should be read by every manufacturer and merchant in the electrical business in this country. We have several times tried to bring the matter of foreign competition, and the need for more energetic pushing, under our readers' consideration; the article to which we refer deals particularly with this subject, and is well worth reading.

The Municipal Electrical Association.—We commend to the notice of the members of this newly-constituted body an article in the *Contract Journal* of the 27th inst., entitled, "Municipal Electrical Engineers." It is as well that they should see themselves as others see them.

The Horseless Carriage Boom.—We have received a copy of a pamphlet entitled, "Self-Propelled Traffic"—"An Easter Egg from Sir David Salomons." Owing to the time which has elapsed since it was laid, we had a suspicion that it had been sat upon for some weeks, or that its contents were addled; but on making the well-known tests to ascertain whether it was a fresh egg, a shop egg, or an egg for political purposes, we have decided that it is a curious mixture of the three. Sir David is acknowledged as being one of the first authorities on horseless vehicles, but he makes such a dead set on eggs—we mean promotion companies—that for the benefit of those who are hesitating whether they shall put money in the horseless carriage business, we extract the yolk:—

> I cannot too strongly impress this upon the public, that they may not risk their money in patents, which so rarely have any value, and which in the case of horseless carriages are absolutely worthless. This I state unhesitatingly, not because it is impossible that on some special point a valid patent might be shown, but from the fact that should such a point exist, a manufacturer could "get round it" by many well-known methods. . . . .
>
> The commercial future of horseless vehicles is likely to have many ups and downs. As I have so often stated before, personally I have no financial interest whatever in this movement, nor am I connected with any company or syndicate formed for the manufacture of these carriages.
>
> I have always held the opinion that manufacturing companies for this purpose are unnecessary in England, as our leading firms are quite strong enough to purchase patents, if that were necessary, can produce an excellent vehicle, and put on the market all that the public is likely to demand. I therefore regard with great suspicion any company which may be formed in this country for the manufacture of these vehicles, professing, as they probably will, to hold extraordinary patents, for which large sums of money have to be paid, and which sums rarely reach the inventors. It is, therefore, well that the investing public, as well as our financial newspapers, should keep a careful watch on any tactics whereby the public may find themselves at a disadvantage. Further than this even, when a financial newspaper writes in favour of any company of this kind, a careful investor will search the recent issues of that journal to ascertain whether the concern so well spoken of has been freely advertised, or in other words, whether the friendly article is really fair or, in his judgment, has been indirectly paid for.

The warning, we fear, is too late, so far as the great horseless carriage boom is concerned.

The Sussmann Electric Miners' Lamp.—We did not refer to the reports of professors and electrical experts in commenting upon this lamp in last week's issue; but none of them, except Mr. Goolden, consider the effect of time. This gentleman mentions "two months" and "about two months," but says nothing as to the condition of the cellulose after that lapse of time. Paper pulp (cellulose or cellulin) was long ago used for telegraph batteries, and we have experimental grounds for believing it to be practically valueless for the purpose now claimed. For a time, especially with very weak acid, cellulose acts fairly well as an absorbent; but the effect of the acid is to gradually convert it into glucose (grape sugar). Peroxide of lead is decomposed by glucose, becoming converted into plumbic formiate and carbonate. (See Miller's "Elements of Chemistry," Vol. iii., p. 100, in 4th Edition.) In the presence of sulphuric acid, however, sulphate of lead is the ultimate product. Cellulose itself, in the presence of sulphuric acid, reduces peroxide of lead, with productions of sulphate of the metal. Then the taking of filtering paper, and scraping or otherwise comminuting it, seems a ludicrous proceeding. Filtering paper is very expensive, being manufactured with extraordinary care (to prevent "pinholes") from the purest cellulin, obtained from linen fibre. Any rational person would, we imagine, use this material at once, instead of manufacturing and then *scraping* it. The boiling "for about an hour in a sulphuric acid solution of about 1 to 10," afterwards washing in water "until all traces of acid have been removed," then boiling "for about one to two hours in a caustic potash solution of about 1 to 50," washing in water "till all traces of that solution have been removed," and, finally, boiling "in alcohol, say, for about half an hour or an hour," is all a delightful bit of fooling, at least when applied to the material the inventor *preferably* uses. It is best never to allow any organic matter, or, indeed, any oxidisable substance, to come into contact with the peroxide element of a lead secondary battery.

The Infant.—The following note, taken from the New York *Electrical Engineer*, will find many an echo on this side of the Atlantic:—"If there is one thing more than another that tires the plain electrical man, it is to be told that his field of work is chiefly characterised by its juvenility. Some remarks he can stand, but that always upsets his equanimity, and he does not need to have read through Dr. Park Benjamin's fine collection of early electrical literature to justify him with evidence to the contrary and warrant for his protest. Scientifically considered, the art is very old, and when it comes to industrial statistics, it is certain that electricity has plenty to produce. Just at this juncture, when the public is talking electricity 'for all it is worth,' it may not be out of place to present a few familiar but concrete facts showing what electricity has actually done. For example, in the United States to-day there are 65,000,000 telegrams sent every year. The telephone exchanges of the country take care of 750,000,000 telephonic conversations every year. There are 2,700 central electric lighting stations in the country, and some 7,000 isolated plants. There are not less than 15,000,000 to 20,000,000 incandescent lamps burning in this country, and the number of arc lamps reaches toward a million. Nobody knows exactly how many motors have gone into use, but if we include fan motors, the figure must certainly touch 500,000. The trolley roads of the country reach 1,000, with 12,000 miles of track and 25,000 cars. The investment in mining plants is estimated to have reached $100,000,000, and in electrical power transmission $50,000,000. All told, the capital represented in the various electrical industries to-day is fully up to $1,500,000,000, all fairly well earning in the main, and much of it handsomely. At least 2,500,000 people in the United States are directly or closely dependent upon electricity for their livelihood and sustenance."

Deterioration of India-Rubber.—Mr. F. W. Birchall (*India-Rubber World*, 13, 39-40) inclines to the theory that the oxidation of caoutchin is one of the causes of the cracking of rubber goods. This caoutchin is soluble in chloroform, but precipitates on adding alcohol. Vulcanisation does not diminish its affinity for oxygen. The compounds used in rubber tend to fill its pores and lessen the opportunities for oxidation somewhat, but substances introduced in the compound are often injurious. Examples are given of injury to the rubber due to antimony sulphide which contained sulphuric acid, and in another case to a vulcanising compound which contained moisture. Excess of sulphur over the amount necessary to vulcanise is liable to cause "bloom" on the finished goods. This may be removed by boiling in caustic soda, but this operation may injure the goods. Oxidisable oils are objectionable in rubber compounds, as the oxidation may go too far. Metallic oxides added for colouring purposes, or left in the cloth after dyeing, may cause injury to the rubber. A table of analyses of sound and damaged rubber shows a very large increase in the percentage of oxygen, and some loss of carbon and sulphur.

Production of Caoutchouc in Brazil.—The *Board of Trade Journal*, quoting a French contemporary, says that American statistics show that the production of caoutchouc in the province of Para (Brazil), which is constantly on the increase, has doubled in the last 12 years, and quintupled in the last 30 years. The production of 1895 was 13·4 per cent. greater than that of 1894, and 10·2 per cent. greater than that of 1893. The value of the exports in 7 stated years were as follows:

Year.	Value. £
1865	8,243,000
1870	10,528,000
1875	15,144,000
1880	18,889,000
1885	29,310,000
1890	36,300,000
1895	46,363,000

The imports of caoutchouc into the United States have increased in about the same proportion as the exports from Brazil; but in 1895, for the first time, the amount of caoutchouc sent from Para to Europe was greater than that sent to the United States. The increase is specially noticeable in England, France and Germany, where Para caoutchouc is in great demand.

The Trenton Falls Water-Power Development.—Writing in the *Electrical Engineer* of New York, Mr. Dunlop discusses the report of Mr. Johnson, M. Am. Soc. C.E., on the utilisation of the West Canada Creek at Trenton Falls. A total fall of 500 feet, with a mean flow of 740 feet per second, is equal to 25,000 H.P., but only 95 feet head can be secured, and the power will be 6,400 H.P. in the turbine shafts, or an electrical energy of 6,000 H.P., of which 5,400 can be transmitted to the City of Utica. To secure the 740 feet of mean flow, a dam will be needed to give the necessary poundage, and check any fluctuation arising from holding back of water by mills higher up stream. The West Canada Creek is cited as an instance where, flowing through a deep gorge, there is no convenience for building mills to use water wheels directly, but by means of electrical transmission the problem becomes very simple. The constant recurrence of such schemes in the American papers makes one envious of the possibilities in a country of great water powers. Another article in the same issue deals with the possibility of making California a manufacturing country by means of electrically transported power from some of the more accessible canyons of the Sierra Nevada. One opinion estimates that 350,000 H.P. may easily be developed. Already the powers developed at Pomona, Redlands, and Folsom, have exceeded their promoters' expectations. Some $1,400,000 has been invested in such plants in California already, and projects are in hand amounting to over $4,000,000 to develop 18,000 H.P. The Pomona scheme, which utilised the San Antonio Canyon, embodies an artificial fall of 387 feet, with wheels, dynamos and transformers, up to 10,000 volts, with pole lines of 16 and 28 miles in length to Pomona and San Bernardino. It is said that the man on duty at the power station in the canyon has little else to do than if he were a lighthouse keeper, by which, we suppose, is meant to be conveyed that his duties are light, which is by no means always the case in a lighthouse, where the regular winding up of the revolving weights and the firing of shots every five minutes in thick weather sometimes make the men fairly busy. On several occasions the San Antonio Company has joined the circuit so as to make a continuous circuit of 85 miles, when it has sent 186 horse-power over the whole circuit, out of the 240 horse-power it possesses on the ordinary circuits. California, with its expensive coal, is a good field for electrical power schemes. At Folsom about 80 per cent. only of the current generated is transmitted on bare wires for 24 miles at 10,000 volts, there being also a double pole line to safeguard against breakdown. The loss of 20 per cent. is due to the comparatively small section of copper employed, but this is considered commercially economical, because of the large amount of power available at Folsom. Schemes for conveying power 100 and 150 miles are now seriously proposed.

The Bullard Transformer.—This is a new transformer, being placed upon the market by the Bullard Electric Company, of Chicago, who claim for it that it offers a higher degree of economy than has yet been considered possible when combined with close regulation. A recent and exhaustive test, made by Prof. H. S. Carhart, of the University of Michigan, on a 20-light or 1,000 watt transformer, is given below:—

Efficiency.	Per cent.	Regulation.	Per cent.
Full load	95·18	Full load	2·52
¾ "	95·11	¾ "	2
½ "	94·47	½ "	1·27
¼ "	91·66		

Watts loss on open secondaries, 23·6; rise in temperature after more than one hour with full load, 21° F. The larger sizes are, of course, proportionately better. All of the Bullard transformers are made with the greatest care, only mica insulation being employed. Before finally taping the coils they are, says a trans-Atlantic exchange, thoroughly saturated and boiled in a compound of the highest insulating qualities, and are then baked to a solid mass by being subjected for several days to a high temperature. The transformers are made either for 2,000 or 1,000 volts primary, as may be desired, and for two reductions on the secondary.

Water Tube Boilers.—Dealing with water tube boilers at the sixth annual meeting of the General Mining Association of Quebec province, Mr. Bonner takes the ground that the water tube boiler is the fittest that survives, and he quotes from Messrs. Galloway's catalogue to prove this. In that catalogue Messrs. Galloway speak to the advantages of their so-called Manchester boiler, which is of water tube type, and is being pushed for high pressure work as more suitable than the Galloway boiler. But this admission must not be taken as in any way involving the Lancashire or other types of shell boilers. The Galloway boiler is not a Lancashire boiler. A Lancashire boiler has a pair of cylindrical furnace or flue tubes from end to end; a Galloway boiler has a pair of furnaces of circular cross section, but beyond the furnaces the flue tube is curiously curved in cross section, and only prevented from instant collapse by means of an immense number of Galloway tubes. No one knows why its makers have so tenaciously adhered to this crude and unscientific form, which is inherently weak, and has never been shown to have any advantage over a plain Lancashire boiler, but has numerous disadvantages. The author, however, was not allowed to have entirely his own way. In the discussion which ensued, it was pointed out how very much less dry was steam from water tube boilers than from Lancashire boilers, and the question of steadiness, also, came in, an accident with the feed apparatus in a battery of water tube boilers having to be met by instant stoppage of work, whereas Lancashire boilers would, says a Mr. Fergie, have carried on for three hours longer. In electric light work especially, this ability to run a long time without feed will often enable a high and short load peak to be got over easily by shutting off the feed and running down a previously high water level. The peak once surmounted feed can be turned on, and steam production kept in check. To use Messrs. Galloway as an argument in favour of water tube boilers is, however, rather too bad. We can scarcely expect them to advocate the Lancashire type for high pressures after so persistently pushing their own special make, and naturally finding their own type unsuitable for high pressures, they condemn the Lancashire boiler also, but entirely without reason, for it certainly has not yet reached the limit of its capacity. No one who really understands the two boilers would admit for a moment that there could be any comparison as between the circular tubes of Lancashire or Cornish boilers and the curiously semi-developed flue tubes known as Galloway.

Under the Streets.—Before the South-West of England District Association of Gas Managers' meeting at Sherborne, Mr. Durkin described the disadvantages gas companies labour under owing to their not receiving notice of the breaking up of the streets, and consequent interference with their mains by other authorities, and he suggested that a short Act of Parliament should be passed making the giving of such notice compulsory. In the discussion which followed the paper, Mr. N. H. Humphrys referred to an accident in New York which illustrated the inconvenience of having the public roads occupied by a great many different things. In that case there were eight different systems in the road—a high pressure steam supply, a gas main 3 feet in diameter, a water main of about equal size, electric light conductors, and other things. The electric light conductor first parted, creating an arc; that got to the gas main and broke it, permitting a large escape of gas; then the water main followed, and next the high pressure steam pipe started in; a general combination of natural forces. He thought that illustrated the difficulty of their position. An electric light conduit alone added to their responsibilities, and it stood to reason that when there were six or eight different systems in a road the risk was much more. Mr. Humphrys thought it very desirable that there should be some understanding between the different authorities.

Röntgen Rays in Mining.—An American exchange says that it is reported that Dr. J. C. Perry and W. C. Cheney, superintendent of the Portland General Electric Company, have been very successful in defining free gold in quartz by means of Röntgen rays, as plainly as if it lay on the surface.

Personal.—M. de Selves, the Director-General of Posts and Telegraphs of France, has been appointed by Presidential Decree of the 23rd inst. Prefect of the Department of the Seine. While congratulating M. de Selves on the highly important position he has been called upon to fill, the Department of Posts and Telegraphs has to regret the loss of a much respected chief who has presided over its destinies for many years. The representatives of the various telegraph companies who attended the Conference Internationale Télégraphique de Paris will be glad to hear of M. de Selves's promotion. They will be sorry, nevertheless, if this new appointment should deprive them of the pleasure of meeting at Buda Pesth the courteous president of the last Conference.

By Presidential Decree of the same date, the position of Director-General of Posts and Telegraphs has been abolished, and the general management of this Department will be placed in the hands of an Under-Secretary of State, subject to the Minister of Commerce, Industries, Posts and Telegraphs. M. Edouard Delpeuch, Deputy, has been appointed to this Under-Secretaryship.

Mr. Thomas Commerford Martin, joint-editor of the New York *Electrical Engineer*, will shortly reach this country as a delegate from the United States to Lord Kelvin's Jubilee. At an extra Friday evening meeting of the Royal Institution on June 19th, Mr. Martin will deliver a lecture, with illustrations, on "The Utilisation of Niagara."

We regret to learn that Professor Elihu Thomson, while riding a bicycle tandem some days ago, had the misfortune to encounter a boulder and break an ankle bone. The same week Mr. Edison trod on a buckle and wounded his foot quite severely. We trust he will soon be able to buckle to.

The Magnetisation of Quenched Steel.—The polished surfaces of steel bars, carbonised by cementation, and highly hardened by quenching, are capable of being scratched by a sewing needle if their carbon percentage is lower than 0·7, or higher than 1·3; but between these proportions the effect of the scratch is not traceable. In the most highly carbonised specimens, however, the scratch is shown by the microscope to be intermittent, and the steel must therefore contain at least two constituents, which may be provisionally termed A and B, of which the former is not scratched by a needle, but will itself scratch glass, whilst the latter is scratched by apatite, and possibly by fluorspar. The colour of A, on a well polished surface, is greyish; that of B is white. A is the hard material which constitutes practically the whole of quenched steel containing 1 per cent. of carbon. The proportion of B increases with the proportion of carbon up to 1·6 per cent. Under the most favourable circumstances a mixture of A and B may be obtained. Such a mixture is *but slightly magnetic*, as with the same material quenched at 800° C. in water at the normal temperature. The intensity of the medical magnetism in such a bar, quenched at 6,000° C. in iced water, was found by F. Osmond (*vide Comptes Rendus*, cxxi., p. 684) to be 345 immediately, and 221 two days after the magnetisation, whilst that of a bar quenched at 800° C. in water at 15° C. was 966 and 814 under similar circumstances. Now since the constituent, A, is known to be magnetic, it may be suspected that B is non-magnetic. In his paper which was read recently before the Paris Academy of Science, Osmond describes the physical properties of different specimens of quenched steel containing varying proportions of the constituents, A and B.

X Rays.—A Reuter telegram says that Mr. Edison, by coating the interior surface of a Crookes tube with crystals of a new fluorescing substance has succeeded in causing the X rays to change to light. No heat is generated, the whole electrical energy being transformed into light. Interviewed on the "X" rays by a *Daily News* representative on his return from South Africa, Professor Crookes said: "The whole of the Röntgen 'X' ray discoveries were made during my absence from England, and although I, owing to my previous work in the same direction, was able to receive the accounts of them without incredulity, yet I assure you that the announcement was as much a surprise to me as to the general public. With regard to the results since published by various British and continental investigators, you will find that many so-called 'novel effects' and 'discoveries' have been already published by me."

Permeability of Iron and Steel.—The permeability of iron and steel to magnetism has recently been the subject and investigation by M. Osterberg, and although it is a subject concerning which there has been much research, and about which many results have been published, the results of this investigation are worthy of brief notice in the *School of Mines Quarterly*, 1896, Vol. xvii., page 118. Osterberg sums up the causes of variation in the magnetic permeability of iron as follows:—Chemical composition, temper, temperature, rapid magnetising and demagnetising, and previous history of the specimen. Samples of steel made by the basic open-hearth process, and containing C 0·07, Si 0·053, P 0·008, S 0·032, and Mn 0·22 per cent., are compared with acid open-hearth samples containing C 1·406, Si 0·077, P 0·032 S 0·032, and Mn 0·470. Osterberg obtains permeability curves for each of these metals after ordinary cooling, annealing hardening followed by annealing and hardening alone. From these curves, and the accompanying numbers, it is seen that the harder the steel, the poorer is the permeability; all the low carbon specimens were superior to any of those with higher carbon, but it is noteworthy that the curves in the former case agreed more closely among themselves than did those of the latter, among which the hardened specimen was far inferior to the others. The harder the steel the more definite will be the curve. Only at temperatures approaching 400° to 600° F. does the iron begin to lose its magnetic properties, the loss being complete to 760°. Rapid magnetisation and demagnetisation heat the metal, and cause loss by "hysteresis," and iron which has been repeatedly magnetised has a slightly increased permeability. It seems to us that in spite of the voluminous search which has taken place upon this subject, both at home and abroad, that there is still room for further work, and that it ought soon to be possible to make some important generalisations, from which working electricians will be able to extract really definite and reliable data.

New Long-Burning Arc Lamp.—Arc lamps for constant potential continuous circuits, designed to burn 150 hours without retrimming, and shorter lamps of similar design, to burn 100 hours without retrimming, have just been announced by the General Electric Company, America. These lamps, according to the *Electrical World*, require about 5 amperes at 80 volts, a resistance adjustable for voltages of 105 to 120 contained in the lamp reducing the normal voltage of a lighting circuit to that required by the lamp. The lamps are sent out adjusted for 110 volts. By confining the arc in a sealed globe an inert gas is formed, reducing the consumption of carbon, and securing longer life. The mechanism of the lamp is simple, requiring no adjustment.

Squaring the Circle.—A friend tells us that recently he had supplied to him a considerable number of square boxes for holding accumulator plates. They were made of a "new rubber," and its plasticity is such that the electrolyte had the effect of gradually bringing about an alteration of form. They lost their squareness, and became perfectly circular, and when the maker was asked what he thought should be done with them, he ingenuously suggested that in future they should each be inserted in a second square box which would resist the tendency of the first to solve the problem of squaring the circle.

The Daimler Engine.—Amongst the patents controlled by the great Horseless Carriage Company are a number covering the Daimler motor. This, Sir David Salomons says, may now be regarded simply as a connecting link with the past on account of its numerous valves, some 12 or 14 in number, and the close proximity of the parts, which renders cleaning and repairs difficult. There are also other objections to this engine, one of them being the trouble in starting it, and Messrs. Peugeot, of Paris, according to Sir David, are now dispensing with this form of motor.

The Paris Opera Accident.—In his report of an accident which occurred at the Paris Opera last week, the correspondent of the *Daily Chronicle* says:—"it was ascertained that a reservoir supplying the electric light had burst." This is only one of the many strange explanations of the accident which have appeared in the press.

A New Electrolyser.—At a meeting of the French Academie des Sciences, on May 18th, M. Moissan presented a note on behalf of M. Tommasi on the subject of a new electrolyser. In this apparatus the cathode is movable and closed by a metallic disc fixed to a bronze shaft, and capable of revolving more or less rapidly between two anodes. The disc does not entirely dip into the bath, so that each part of the falling ozone is alternatively in the air and the liquid. It is claimed that polarisation is avoided, and that the electrical resistance of the bath is largely diminished.

Electricity in the Austrian Navy.—Quite an elaborate electrical installation is to be carried out on the four new war vessels for the Austrian navy. As not only will the vessels be lighted throughout by electricity, but electrical energy is to be utilised for the manœuvring of the guns and for driving the ventilating plant. The contract for the necessary dynamos and ventilators, &c., has been secured by Messrs. Ganz & Co., of Buda Pesth, while the Ersten Brunner Maschinenfabrik, of Brünn, will supply the engines.

Röntgen Rays.—An American exchange says that the large number of abstracts which are contained in the April number of the *Proceedings* of the Physical Society of London, are classified under the general heading of "light" and not under "electricity." If this was done at the suggestion or with the consent of any number of the officers of the society, the list of which includes many of the most prominent English physicists, it might be taken as an interesting prophecy.

By Unit or Time?—A correspondent would be glad to learn how he is to charge for designing a dynamo, getting out the specification, and making a set of working drawings; whether at so much per unit of output, or for the length of time it takes to accomplish? So far as the first method is concerned, it strikes us that the size of the dynamo would be an important factor to take into consideration; and as for the second, much would depend upon his experience and quickness. Perhaps a unit-time charge would meet the case!

Fined under the Locomotive Act.—Mr. Walter Bersey was last week fined 40s. and costs by Sir John Bridge, at Bow Street, for riding, in company with three other persons, a four-wheeled carriage, propelled by electricity, at the rate of about five miles an hour upon the public thoroughfare. Defendant, who pleaded ignorance of the law, said he had driven such vehicles for the last five years over 5,000 miles, and had never been stopped before.

NEW COMPANIES REGISTERED.

British Thomson-Houston, Limited (47,982).—This company was registered on May 18th, with a capital of £240,000 in £10 shares (4,000 A and 20,000 B) to enter into agreement with a company of the same name to acquire certain patent rights, patents, concessions, &c., and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, and electrical apparatus manufacturers. The subscribers (with one share each) are:—C. Burrell, 59, Rue de Provence, Paris, banker; E. Lazarus, 52, Threadneedle Street, E.C., bank manager; W. A. McArthur, 18, 19, Silk Street, E.C., merchant; J. T. Merz, The Quarries, Newcastle-on-Tyne, manufacturer; T. R. Thompson, 67, Cornhill, E.C., merchant; E. Thurnauer, 38, Parliament Street, S.W., engineer; H. Lee, 27, Sarfield Road, S.W., accountant. The number of directors is not to be less than three, nor more than 12; the subscribers are to appoint the first; qualification, £500; remuneration £1000 per annum; others £200 each per annum and a share in the profits divided. Registered by Ashurst and Co., 17, Throgmorton Street, E.C.

London Electric Omnibus Company, Limited (47,990).—This company was registered on May 18th with a capital of £250,000 in £1 shares, to adopt agreements with R. Ward and the Sola Accumulator Company, and to carry on the business of electricians, electrical and mechanical engineers, suppliers of electricity, omnibus and carriage builders, tool makers, electric apparatus manufacturers, wheelwrights, metal workers, &c. The subscribers (with one share each) are:—S. F. Page, 102, St. George's Square, S.W., retired major; H. Fox, 32, Victoria Street, S.W., solicitor; J. B. W. Maunder, Broad Street House, E.C., merchant; T. S. Flack, 2, Royal Exchange Buildings, E.C., merchant; M. R. Ward, Trafalgar Buildings, Charing Cross, W.C., engineer; A. Caillat, Broad Street House, E.C., accountant; W. Marshall, 16, Tokenhouse Yard, E.C., engineer. The number of directors is not to be less than three nor more than eight; the subscribers are to appoint the first; qualification, £250; remuneration, £3,000 per annum, and a share in the profits divided. Registered by Bircham & Co., 50, Old Broad Street, E.C.

Manchester Electrical Works, Limited (47,986).—This company was registered May 18th, with a capital of £1,000, in £1 shares, to carry on the business of electrical engineers, electricians, suppliers of electricity, and manufacturers of, and dealers in, electric, surgical, and scientific apparatus. The subscribers (with one share each) are: W. Pirrie, South View, Streatham, merchant; W. Brown, 48, Hungerford Road, N, clerk; F. C. Sanders, 33, Cornhill, E.C., engineer; A. W. Smedmore, 6, The Crescent, Stamford Hill, N., clerk; F. Johnson, The Crescent, South Tottenham, printer; F. G. Phillips, 4, Myrtle Villas, Leyton, printer; F. Weeks, 140, Sewardstone Road, Victoria Park, N.E., warehouseman. Table "A" mainly applies. Registered without articles of association by F. T. Easton, 33, Cornhill, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Oriental Telephone and Electric Company, Limited (40,691).—This company's annual return was filed on May 13th. 171,504 shares have been taken up out of a capital of £200,000, in £1 shares; £1 per share has been called and paid on seven, and the rest have been issued as fully paid.

Corlett Electrical Engineering Company, Limited (36,200).—This company's annual return was filed on May 15th. 620 shares have been taken up out of a capital of £10,000, in £10 shares. 100 of these are considered as fully paid, and £5,200 has been paid on the rest.

Norwich Electricity Company, Limited (30,694).—This company's annual return was filed on April 29th; 3,525 shares have been taken up out of a capital of £50,000 in £10 shares, the full amount has been called, and £35,250 has been received.

Hastings and St. Leonard's-on-Sea Electric Light Company, Limited (16,505).—This company's annual return was filed on May 9th. The capital is £50,000 in £10 shares, and 2,722 have been taken up, the full amount has been called, and £27,225 has been paid, which includes a sum of £5 received in respect of five forfeited shares.

Telephone Company of Egypt, Limited (17,824).—This company's annual return was filed on May 13th. The capital is £100,000 in £5 shares (of which 16,000 are preference and 4,000 deferred). 12,071 of the preference, and all the deferred have been taken up. £5 per share has been called and paid on 71 preference and the rest have been issued as fully paid.

CITY NOTES.

St. Pancras Abolish Meter Rents.

We are glad to see that the Vestry have decided to abolish rents for meters, switches, &c., on consumers' premises. It is not every undertaking that could afford to do this, but in going through electric lighting accounts we have often thought that meter rents were occasionally excessive, even when taking into consideration the interest on capital account and the charges that could be fairly reckoned for maintenance. There were other features of interest concerning the electricity works which were brought forward at the last meeting of the Vestry. One was the recommendation of the Electric Lighting Committee to hand over £1,000 to the Vestry towards reduction of rates.

We are sorry to record that on the same occasion Mr. Sweet, who has been chairman of the Electric Lighting Committee from the inception, resigned his position, the reason assigned being that Mr. Sweet is taking up electrical work. We trust that he will be as successful in his own electrical work as he has been in the guidance of the public work of the Vestry.

New Issue of Willans and Robinson.

It is a pleasure to have to deal in our "City" columns with such sound industrial concerns as Willans & Robinson, especially in these days of speculative companies and unsound finance. We would draw the attention of our readers to an issue of £100,000, in £100 4½ per cent. Mortgage Debenture Stock, the list for which opens on June 1st, and closing on the following day. The stock is secured by a charge upon the undertaking, and upon all the property and assets of that company, the value of which stood in the last balance-sheet at £216,368. The stock is repayable at par on May 31st, 1921, or at the option of the directors, on giving six months notice at any time after May 31st, 1906, at the rate of £105 per £100 stock. We need hardly say that this company has achieved extraordinary success in the past, and there is no reason why it should not continue to be eminently successful. Full particulars of the issue will be found in the "Advertisement Supplement."

Dewsbury Corporation Accounts.

Those that are acquainted with the local conditions that prevail in Dewsbury will not be surprised that the first year's working of the Corporation Electricity Works have resulted in a deficit. There are some long streets in Dewsbury, with never a customer for the electric light. Still the results for 1895 are hopeful for the future. The revenue account shows a small net profit of £93, and as an increase of output will not materially alter many of the generation expenses, Mr. Mitchell may yet show something like a substantial profit. The amount transferred from the district rate to the end of September, 1895, was £940 12s. 6d. The following table shows the cost of production:—

	1893.	1894.	1895.
Total capital invested	—	—	£20,502
Number of units sold	—	—	58,109
Number of lamps connected ...	—	—	—
Revenue from sale of current...	—	—	£1,385
Net revenue	—	—	£93
Average price obtained per unit	—	—	5·6d.

Cost of production.	£	s.	d.	Per unit.
Coal	238	0	0	·98d.
Oil, waste, water and engine room stores	54	0	0	·22d.
Salaries and wages at generating station	344	0	0	1·42d.
Repairs and maintenance of buildings, engines, boilers, dynamos, &c.	158	0	0	·64d. (Works' cost 3·26d.)
Rates and taxes	43	0	0	·18d.
Management expenses, directors' remuneration, salaries of managing engineer, secretary, clerks, &c., stationery and printing, general establishment charges, auditors, law charges, and insurance	391	0	0	1·61d.
Depreciation of buildings and plant account	—			—
Renewal fund account	—			—
Total	£1,228	0	0	4·05d.

Revenue.	£	s.	d.	Average price obtained per unit.
By sale of current	1,385	0	0	5·62d.
Meter rents	47	0	0	—
Sale of lamps	—			—
Total	£1,432	0	0	5·62d.

Total cost per unit (exclusive of depreciation and renewal accounts), 4·05d.; works' cost, 3·26d.

The West Coast of America Telegraph Company, Limited.

The report of the directors and accounts for the year ended December 31st, 1895, to be presented at the nineteenth ordinary general meeting, May 29th, 1896, states that the directors beg to place before the shareholders the accounts of the company for the year ended December 31st, 1895. The gross income for the year 1895, as shown in the revenue account, was £32,930 5s. 9d., as against £21,753 12s. 2d. in 1894. The traffic receipts during the past year were adversely affected by the stagnation in the nitrate industry, and other local causes, but owing to a readjustment of the proportions of the international traffic receipts for the year, the income of the company was sufficient to pay the expenses and the interest on the debentures. The total expenses were £20,930 5s. 9d., against £20,154 4s. 11d. in 1894. The company's repairing steamer *Retriever* has been fitted with a new steel main boiler, the cost of which, £1,978 0s. 3d., has been charged to the reserve fund. The steamer is now considered to be in first class condition and, outside of accidents, fit for service for the next 12 years. The company's cables and landlines are maintained in good working order. The members of the board retiring, in accordance with the articles of association, are Mr. J. Denison Pender and Mr. Fredk. Walters; both are eligible, and offer themselves for re-election. The auditor, Mr. John Francis Clarke, retires, and is eligible for re-election.

The German (Popp) Compressed Air Company.

A perusal of the report for 1895 of the Internationale Druckluft und Elektricitats Gesellschaft (Popp) show that the operations of the company were mainly devoted to advancing the interests of the Compagnie Parisienne de l'Air Comprimé, Paris. The balance-sheet of the latter on June 30, 1895, does not afford any pleasant reading. It shows, after the payment of 1,316,182 francs as interest, and writing off 11,363 francs, a debit balance of 1,164,726 francs, thus bringing the total debit up to 2,483,962 francs. Since then the technical and administrative reorganisation of the Paris board has been carried out and has up to the present fulfilled expectations. The economy practised by the new administration during the first eight months of the current year has brought about an essential reduction in the working expenses simultaneously with an increase in the receipts. This will be readily understood from the following figures, given in francs, concerning the receipts and expenses from July 1st to March 1st, in 1894-5, and 1895-96.

	1594-5. Francs.	1895-6. Francs.
Receipts	2,190,164	2,345,551
Working expenses	1,968,770	1,762,863
Profit	221,394	582,688

The report goes on to say that the negotiations for the formation of a syndicate to make advances to the Paris Company to the extent of 7,000,000 francs for the extension of the operations of the district stations have been brought to a conclusion. The syndicate has been constituted under the auspices of the Diskonto Gesellschaft, of Berlin, and almost all the shareholders have participated in the issue according to the proportion of their original holdings. The money thus provided has allowed of the installation of three large generators in the Paris central station, although it was only possible to start these in March of the current year. Notwithstanding this delay, the number of 16 C.P. lamps connected to the mains increased from 59,000 in March, 1895, to 81,000 in March, 1896, and a further considerable advance is expected in the coming winter. At the close of the present financial year, a considerable surplus on the working of the Paris Company is anticipated. The profit of the German Popp Gesellschaft allows of the reduction of the debit of the previous year from 2,302,285 marks to 2,251,923 marks.

Reuter's Telegram Company, Limited.

The ordinary general meeting of Reuter's Telegram Company, Limited, was held on Wednesday at 24, Old Jewry, Admiral Sir John C. D. Hay presiding.—In moving the adoption of the report, the Chairman congratulated the shareholders on the improved state of the company's finances. When he addressed them last year, he had predicted that they should be able to resume the payment of the autumn dividend. Not only was this anticipation fulfilled, but they were in a position to declare a balance dividend for 1895. Some of them might think the circumstances called for the declaration of a larger dividend, but the directors had carefully considered this point, and had unanimously concluded that the best interests of the company demanded that the reserve should be strengthened to the utmost, and this policy they intended to pursue in the future. In these times, when it was difficult to obtain a return of even 3 per cent on investments, a yield of 5 per cent. could not but be considered satisfactory, and he felt sure that shareholders would agree with them as to the wisdom of putting the balance by. While he was pleased to say that the company's prospects continued bright, he wished to point out that the maintenance of their present satisfactory state could only be counted upon so long as business remained good, for it was to the extension of commercial enterprise that the increased profit in 1895 was due. The only other matter to which he need make allusion was the advertisement branch. The board had decided, after all, to retain this business, in view of the encouraging reports received from colonial agencies. He might state that no further outlays would be necessary.

The motion was seconded by Baron de Reuter, and the report was unanimously adopted.

Liverpool Electric Supply Company, Limited.—The directors of this company have issued a circular to the shareholders stating that the Act of Parliament confirming the sale of the undertaking to the Corporation of Liverpool has now received the Royal assent, and that the completion of the purchase will take place on July 1st next. On that day the company will post to the shareholders cheques for £8 5s. per share, being £8 2s. in respect of capital, and 3s. for dividend at the rate of 6 per cent. from January 1st to July 1st.

Stock Exchange Notices.—The Stock Exchange Committee has ordered the undermentioned securities to be quoted in the Official List:—India-Rubber, Gutta-Percha and Telegraph Works Company, Limited, £300,000 4 per cent. first mortgage debentures, Nos. 1 to 3,000 in lieu of the £200,000 4½ per cent. debentures now quoted. Willans & Robinson, Limited, 22,500 6 per cent. cumulative preference shares, Nos. 30,001 to 52,500; and 22,500 ordinary shares, Nos. 1 to 22,500.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending May 24th, 1896, were £893; week ending May 26th, 1895, £884; increase, £9; total receipts for half-year, 1896, £19,693; corresponding period, 1895, £19,604; increase, £89.

The Liverpool Overhead Railway Company. The receipts for the week ending May 24th, 1896, amounted to £1,178; corresponding week last year, £1,135; increase, £43.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending May 22nd, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company Limited, were £2,710.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation May 20th.	Closing Quotation, May 27th.	Business done during week ended May 27th, 1896. Highest.	Lowest
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	4 %	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	10 — 11	10 — 11	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 11s.	£2 2s.	£2 9s.	48 — 50	48 — 50	...	...
2,993,560£	Do. do. 6 % Pref.	Stock	£5 2s.	£4 4s.	£4 18s.	91½— 92½	91½— 92½	92	91½
2,993,560£	Do. do. Defd.	Stock	...	...	...	9½— 9¾	9 — 9½	9¼	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½%	7 %	...	14¾— 15¼	15 — 15½	15¼	15 1/16
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	113 —117	113 —117	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	...	2½%	...	3 — 3½	3 — 3½	3 7/16	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —170	160 —170	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 %	1½%	...	1/16— 3/16	1/16— 3/16	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12 — 13	12 — 13	12⅝	12¼
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19½— 20½	19½— 20½	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	4 — 5	4 — 5	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	10⅛	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	4½%	4½%	106 —109 %	105 —109 %	107½	...
60,710	Direct United States Cable, Ltd.	20	2⅝%	2 %	...	9½— 10	9½— 10	9 11/16	...
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½%	6½%	...	17 — 17½	17 — 17½	17 7/16	17⅛
70,000	Do. 6 % Cum. Pref.	10	6 %	6 %	...	18 — 18½	18¼— 18¾	18¼	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	106 —109	106 —109	...	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	...	130 —133	130 —133	133	132
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	17¾— 18¼	17¾— 18¼	17 13/16	...
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	101 —105	101 —105	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	102 —105	102 —105	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	131 —134	131 —134	133¾	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	101 —105	101 —105	...	...
107,600£	Do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	102 —105	102 —105	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	105 —108	105 —108	105	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	110 —113% xd	110 —113 %	...	...
180,227	Globe Telegraph and Trust, Ltd.	10	4⅜%	4⅛%	...	10½— 11	10½— 11	10⅜	10⅛
180,042	Do. do. 6 % Pref.	10	6 %	6 %	...	17 — 17½	17 — 17½	17 5/16	17⅛
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	8⅜%	10 %	23 — 24	23 — 24	...	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	52 — 55	52 — 55	54	53
100,000£	London Platino-Brazilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	109 —112	109 —112	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2⅛	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 %	5 %	5½%	7⅜ — 7⅝	7¼— 7½	7⅛	7¼
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	16 — 18	16 — 18	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	16½— 17½	16½— 17½	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6⅝ — 6⅞	6⅝ — 6⅞	6 13/16	6⅝
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	107 —110	107 —110	108½	107¼
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	4¼%	5 %	1/16— 3/16	0/16— 3/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 — 111	108 —111	...	...
11,839	Reuter's Ltd.	8	0 %	*nil*	5 %	6 — 7	6½— 7½	6¼	...
3,381	Submarine Cables Trust	Cert.	...	...	...	135 —140	135 —140	...	...
58,000	United River Plate Teleph., Ltd.	5	...	3 %	...	3½— 4	3½— 4	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	...	98 —103	99 —104	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	*nil*	*nil*	4 %	6 — 7	7½— 8½	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	102 —105	103 —106	...	...
30,000	West Coast of America Teleg., Ltd.	10	*nil*	*nil*	*nil*	1 — 2	1 — 2	1 1/16	1¼
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	8 %	97 —102	99 — 104	...	...
64,248	Western and Brazilian Teleg., Ltd.	15	2½%	3 %	3 %	9¼— 9⅝	9¼— 9⅝	...	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	6⅝— 7¼	6⅝— 7¼	7 1/16	6 15/16
33,129	Do. do. do. Def. Ord.	7½	...	1 %	1 %	2½— 3	2½— 3	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	104 —108	104 —108	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	104 —108	104 —108	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅜%	⅛%	⅜%	1⅛— 1⅜	1⅛— 1⅜	...	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	11½— 11¾	11½— 11¾	11¾	11½
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	9½— 10½	9½— 10½	...	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	108 —111	108 —111	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115 xd	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	102 —105	102 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	4½%	5 %	8 — 8½	8½— 8⅝	8½	...
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	7½— 8	7½— 8	8	7⅞
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	4 %	116 —119	116 —119	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	5 %	5 %	14½— 15½	14½— 15½	15⅝	...
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½— 17	16½— 17	...	...
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	134 —138	134 —138	...	...
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	*nil*	8½— 9½	8½— 9½	...	...
10,000	Do. do. do. 6% Pref., £8 pd., 40,001—50,000	10	...	...	6 %	12½— 13½	12½— 13½	12 15/16	12⅞
50,000	†Liverpool Electric Supply, all paid	5	5 %	5½%	6 %	8 — 8¼	8 — 8¼	...	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	2½%	3 %	4 %	14 — 15	14 — 15	14⅝	14 1/16
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	120 —123	120 —123	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	1 %	2 %	9 — 9½	9 — 9½	...	...
19,980	St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	4½%	6½%	7½%	10½— 11	10½— 11	10⅝	...
20,000	Do. do. 7 % Pr f., 20,081 to 40,080	5	7 %	7 %	7 %	10 — 11	10 — 11	...	...
67,900	*Westminster Electric Supply Corp., Or f., 101 to 60,000 ...	5	4 %	5 %	7 %	9½ — 10	9½ — 10	9⅞	...

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

Unless otherwise stated all shares are fully paid. ‡ Dividends paid in deferred share warrants, profits being used as capital.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, May 20th.	Closing Quotation, May 27th.	Business done during week ended May 27th, 1896. Highest.	Lowest
£90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	3	5 %	2½%	...	1⅛— 1⅜	1⅛— 1⅜	...	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 %	3 %	...	1⅜— 1⅝	1⅜— 1⅝	...	...
125,000£	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	4½%	...	111 —114	111 —114	...	...
630,000£	City and South London Railway	Stock	11%	11%	1 5/16%	42 — 44	42 — 44	...	...
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	3 %	*nil*	...	2 — 2½	2 — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	7 %	5 %	...	1½— 1⅝	1½— 1⅝	1⅝	...
17,139	Do. do. do. "A" Shares 01—017,139	5	7 %	5 %	...	2½— 3½	2½— 3½	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	...	4½%	...	104 —107	104 —107	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	...	1½— 1⅝	1½— 1⅝	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	2½— 3	2½— 3	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	5/8— 7/8	5/8— 7/8	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	½— ¾	½— ¾	...	...
9,600£	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	*nil*	...	9½— 10½	9½— 10½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	6 %	8 %	16 — 17	16 — 17	16⅞	16⅝
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	17 — 18	17 — 18	17⅞	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	4½%	109 —114	109 —114	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	10 %	10 %	23½— 24½	23 — 24	23⅝	23½
37,500	†Liverpool Overhead Railway, Ord.	10	1 %	1½%	2⅜%	14 — 14½	14½— 14¾	14⅛	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	17⅛— 17⅝	17⅛— 17⅝	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	20 %	15 %	38 — 41	38 — 41	40	38½
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	102 —105	102 —105	...	...
54,000£	Waterloo and City Railway, Nos. 1 to 54,000, £6 paid ...	10	...	...	...	8¼— 8⅜	8 — 8⅛	8⅛	8¼

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.
Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—⅞%§ 1890—5%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 6—6½.

Electric Construction Corporation, 6 % Debentures, 102—106.

House-to-House Company (£5 paid), 3⅜—4¼.

Do. do. 7 % Preference, of £5, 8¼—8⅜.

Do. do. 4½% Debentures of £100, 110—112.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 9—9½; 1st Preference Cumulative 6 %, £5 (fully paid), 7⅞—8¼.

Liverpool Electric Supply, £5 (fully paid), 7⅞—8¼.

London Electric Supply Corporation, £5 Ordinary, ¾—1¼.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 7½—8.

Bank rate of discount 2 per cent. (February 22nd, 1894).

PROCEEDINGS OF SOCIETIES.

Physical Society.

Ordinary Meeting, May 8th, 1896, Captain Abney, President, in the Chair.

Messrs. Frith & Rogers read a Paper on the True Resistance of the Electric Arc.

It was pointed out by Prof. Ayrton, at the British Association meeting at Ipswich, that if the "true resistance" of an arc is defined as the ratio of a small increase of the P.D. between the carbons to the corresponding change in the current, then it follows that this "true resistance" must be a negative quantity.

In order to measure the "true resistance," without appreciably altering the form of the carbons, &c., the authors superpose a small alternating current on the main continuous current. The arc lamp employed was adjusted by hand, and the arc length was measured by projecting an image of the arc by means of a lens. The main (continuous) current and P.D. were measured by a Weston ammeter and voltmeter, while the auxiliary alternating current was measured by means of an air transformer and an electrostatic voltmeter.

The authors find that between the limits employed the magnitude of the alternating current did not influence the results obtained for the resistance of the arc. The frequency, so long as it lies between the limits 250—7 complete alternations per second, and the wave form do not influence the resistance, since the same results were obtained with a Pyke and Harris alternator, a Ferranti alternator, a Gramme alternator, and a Mordey transformer.

For each make of carbon examined four combinations were used:—+ cored, − cored; + cored, − solid; + solid, − cored; + solid, − solid. The general character of the curves obtained is that for the + solid, − solid combination the "true resistance" is always negative, while for + cored, − cored it is always positive, the other curves lying between these two extremes, those which have the + carbon solid always being more negative than those which have the + carbon cored.

In the case of the curves showing, for solid carbons, the relation between the resistance of the arc and the P.D. between the carbons, the current being constant (10 amperes), a minimum (maximum negative) value for the resistance occurs at about 55 volts. With combinations having a cored positive this minimum becomes more strongly marked, and occurs at a lower voltage. The authors find that for cored carbons the position of this minimum is closely connected with the presence or absence of the dark space in the arc. For points on the curve to the right of the minimum point the dark space is absent, while for points to the left of the minimum the dark space is always present.

It was found that the effect of using as the + carbon a Carré carbon in which the core had been bored out, was to obtain a curve closely resembling that obtained when both carbons were solid. On filling this hollow carbon with plaster of Paris or kaolin, the resistance of the arc became positive.

The above experiments were made with the + carbon uppermost; other experiments made with the arc inverted showed that with solid carbons the resistance is not appreciably altered by inverting the arc. With cored carbons, however, the resistance as well as the physical character of the arc, is altered, for on inversion the dark space disappears, and the resistance considerably diminishes. If, however, the conditions under which the arc is burning are such that the dark space is absent, then inverting the arc does not alter the resistance.

Attempts were made to measure the "true resistance" of a direct current hissing arc, but it was found that even with the alternator at rest there was a large deflection of the electrometer, showing that the current through a hissing arc was oscillatory.

In order to elucidate the marked difference between their results for cored carbons and those deduced from Mrs. Ayrton's curves, the authors have made a series of measurements at low frequencies. They find that there is a critical frequency above which the resistance has a positive value which is independent of the frequency, and below which it has a negative value; this critical frequency being between 7·5 and 0. In order to investigate the sign of the resistance at low frequencies, the vibrations of the needles of the ammeter and voltmeter were made use of. By an arrangement of mirrors, the needles and scales of both instruments could be observed simultaneously. In this way, it could be seen whether the two needles were, at any instant, vibrating in the same or in opposite directions. If the needles vibrate in the same phase, *i.e.*, if an increase of P.D. is accompanied by an increase of current, then the resistance must be positive; while if they are vibrating out of phase, *i.e.*, if an increase of P.D. is accompanied by a decrease in current, then the resistance is negative.

An attempt to run the arc off a continuous current dynamo failed, since even with the alternator at rest the electrometer showed a large deflection, evidently due to the oscillation of the current, owing to the commutator of the dynamo having a finite number of segments.

Professor A. Gray doubted whether it was right to give the name "true resistance" of the arc to the slope of the curve connecting the potential difference (V), and the current (A). The author's method of deducting $\frac{d\,v}{d\,a}$ was only true if the curve was a straight line, while in the case of the arc v and a may both vary with the current.

Mrs. Ayrton said that with reference to the question of the existance of a back E.M.F., the evidence tended to show that it did not

exist. By using an exploring carbon, no constant back E.M.F. could be found.

Professor AYRTON said that considering the arc as consisting of a back E.M.F., and a resistance, it was necessary to separate these two. Simply obtaining one value of the P.D., and the current was of no assistance in solving this question, but a series of values had to be taken. By taking the change in P.D. and current sufficiently small, the curve over the range considered was practically straight. It was curious to note that as long as observers obtained a positive value for the resistance of the arc no fault was found with the method, but that now a negative valve was found the accuracy of this method was questioned. If a back E.M.F. does really exist then it follows that the arc must have a negative resistance. Mr. Frith has shown why some people have got some positive and negative values for the resistance of the arc, and also that with an alternating current you may get either one or the other.

Mr. T. CARTER asked if the fact that the arc had a negative resistance did not imply a back E.M.F. in order that the arc might be stable. If so, was a negative resistance such an absurdity?

Mr. CAMPBELL said he was very pleased to see that the authors had applied a method which he (Mr. Campbell) had suggested for measuring pulsating currents. If a pulsating current such as could be obtained by means of a make-and-break, is passed through a thermopile, you would get a back E.M.F., while if an alternating current were employed you would not.

Mr. FRITH, in his reply, said that he had defined the "true resistance as $\frac{d\,v}{d\,a}$. Mrs. Ayrton has shown that an arc will not run unless a certain resistance is placed in series with it; this resistance must be numerically equal to the negative resistance of the arc itself.

Prof. AYRTON said Mr. Frith's remarks as to the cause of the want of stability of an arc without outside resistance were most suggestive.

The CHAIRMAN (Captain Abney) said he did not like the expression P.D. He suggested the employment of photography to facilitate the accurate registration of the instrument readings.

The further discussion on the paper was adjourned till the next meeting on May 22nd.

ORDINARY MEETING, MAY 22ND, 1896.

Prof. AYRTON, Vice-President, in the chair.

Mr. R. APPLEYARD read a paper on DIELECTRICS.

The author has particularly investigated the effect of temperature on dielectric resistance. He has employed for this purpose condensers insulated with mica and paraffined paper. In order to eliminate some of the effects of surface leakage, Price's guard ring arrangement was made use of in all the experiments.

The author finds that the capacity of a paraffin condenser varies irregularly with the temperature, but that to within the accuracy attainable with his instruments (1 per cent.), the capacity of a mica condenser is constant between 33° F. and 110° F.

If the resistance of paraffin at a temperature, t, is represented by $R_t = R\,\alpha^t$, the mean value for log. α, deduced from all the author's measurements, is $\bar{1}\cdot96344$.

Experiments made with a parallel plate condenser with paraffin as the dielectric, show that when the temperature reaches within about 20° of the melting point, the resistance rapidly falls; when melting commences there is a rapid drop, but while melting is in progress the resistance remains constant.

Prof. AYRTON said he could bear witness to the extreme value of Mr. Price's device, as it completely did away with the necessity for the extreme care previously necessary to prevent errors due to surface leakage. He regretted that he had not had an opportunity of comparing the author's numbers with some obtained some years ago by Prof. Perry and himself.

A paper by Prof. VIRIAMU JONES, on THE MAGNETIC FIELD DUE TO AN ELLIPTICAL CURRENT AT A POINT IN THE PLANE OF THE ELLIPSE, AND WITHIN IT, was taken as read.

Prof. SILVANUS THOMPSON said that this paper was of interest, not only on account of the application which others might make of the author's method, but also in that the correction, when applied to Prof. Jones's results, brought the international ohm more nearly into accord with the true ohm.

Mr. J. J. WALKER said he considered that the paper was more suited to the Mathematical Society. The integration, which the author reduced to elliptic integrals, might be more easily performed by another method.

Prof. AYRTON said that Prof. Jones's value for the true ohm was now 106·302 cm. of mercury.

Mr. CAMPBELL read a paper on NEW INSTRUMENTS FOR THE DIRECT MEASUREMENT OF THE FREQUENCY OF ALTERNATING OR PULSATING ELECTRIC CURRENTS.

The author employs two arrangements, in one of which a steel wire, the tension on which is variable, and the other a steel spring of variable length, clamped at one end, are acted upon by an electromagnet, through which the periodic current is passed. The tension or length, as the case may be, is varied till maximum resonance is obtained, a small contact piece being employed to detect when this occurs. The instrument exhibited was capable of measuring the frequency of periodic currents of from 40 to 150 double vibrations per second.

Mr. WATSON said he thought that in the case of the steel spring there would be a considerable temperature correction, and he suggested a method by which this might be compensated.

Mr. BLAKESLEY asked if the author had found that the spring became magnetised, and thus gave the octave.

Mr. CARTER asked whether elastic fatigue influenced the results, and said that a synchronous motor and a speed indicator could be used to measure the frequency.

Prof. SILVANUS THOMPSON suggested that it might be better to employ a polarised apparatus, since to avoid the impression of forced vibrations on the spring, it was better, as was done in the case of tuning forks, to make it massive. It had been found in other cases, such as in Hughes's telegraph and the telephone, that better results were obtained with polarised apparatus. He (Prof. Thompson) had used a telephone, placed anywhere near a magnet traversed by the periodic current, together with a tuning fork, which gave beats with the note produced by the telephone, to measure frequencies. The variations in frequency ordinarily met with in practice were much greater than was generally suspected.

Mr. BLAKESLEY said he considered that the advantage of the author's instrument over a telephone and tuning fork was that it was continuously variable over a large range.

Mr. ENRIGHT asked if the author had been troubled by the spring or wire breaking into overtones. In some experiments in which rather long wires were used, he had been troubled in this way.

Prof. AYRTON said that he did not think that it was possible to get the wire or spring to respond to the octave unless the alternating current contained a component of the frequency of the octave. In fact, he had himself used such a stretched string as a wave analyser. He had used a telephone to prove that the note given by a hissing alternate current arc corresponded in frequency to that of the current. In the instrument used by Prof. Perry and himself, a polarised arrangement was always employed, since the alternating current was passed either through a wire in a constant magnetic field, or through an electro-magnet which acted on a wire through which a constant current was passed.

The AUTHOR, in his reply, said that the instrument responded, though feebly, to the octave, and this response might be made use of to check the accuracy of the scale.

The Society then adjourned till June 12th.

The Northern Society of Electrical Engineers.

ON THE USE AND ECONOMIES OF RECTIFIERS FOR ARC LIGHTING, read by JOHN HESKETH, Member of Council, May 11th, 1896.

The first practical use of electrical energy for lighting purposes was by means of arc lamps, and this method still remains to-day the most economical means of lighting possible in the present state of our knowledge.

It is only reasonable, therefore, to expect that the theory and practice of arc lighting, and the knowledge of the arc lamp with its accessories and special plant, should be the most fully developed and perfected of all our electrical knowledge.

But such, unfortunately, is not the case. Of all the existing systems of arc lighting, whether public or private, scarcely one exists in which some glaring inefficiency does not appear.

The fact that we have all known of this lamentable condition of affairs for many years in a dim uncertain way has perhaps hardened our hearts, and made us condone a technical sin, sanctioned by common consent.

Perhaps, too, the fact that, until recently, arc lighting has not been very largely adopted in England has influenced our views; the result, from whatever cause, has been that, speaking broadly, the thought and care given to machines, systems, and schemes for incandescent lighting has not been extended, except in a half-hearted way, to arc lighting.

In England arc lighting has been a side show, and incandescent lighting the main purpose of electricity works; and even in America, where in many stations the order is reversed, the inefficiencies still exist—but it is only fair to admit, in a greatly reduced degree.

It is not with any intention to discuss the whole of this problem that the present paper is undertaken, but only to detail recent experiences in the use of one special form of apparatus and system of generating the necessary energy. The question of distribution and utilisation of such energy in arc lighting is sufficiently wide to form matter for papers for a complete session.

In special reference to the subject of this paper, it is interesting to note that the first arc lamps used in French lighthouses were supplied from alternators fitted with commutators, and so were virtually rectified current arc lamps.

In the earliest installation of public arc lighting plant in England, of which I think Blackpool was the first example, the practice was to run each lamp from a separate machine; so that, in such a station, one or more engines running on to a counter-shafting drove the dynamos and exciters. Each dynamo feeding its own arc lamp through a separate lead, and a common uninsulated and buried return.

That such a system of generation was most inefficient is very apparent—the system of distribution and utilisation of light was perhaps equally so; and it was not long before the system, not only of distribution, but of generation, was altered completely. Installation of arcs connected in series and run from special machines, such as Brush or Thomson-Houston, began to appear, and although the machines were admittedly inefficient, and in their ordinary sizes have not been much improved, they still continue to be most generally in use.

We are aware that recently the efficiencies obtained in America by the use of 50 to 55 kw. Brush dynamos (100 to 110 arc machines) has

risen considerably above any known in England, but the conditions of practise there are widely different from those in England.

The need for a public supply of incandescent lighting led, in one or two instances, to the expedient of running incandescent lamps in series with arc lamps from Brush machines, but as the demand for private lighting increased much more rapidly than that for public lighting, separate machines and systems gradually were adopted and the question of generation for series arc lighting was allowed to lapse for a while. But recently, the fact has been recognised that two different types of generating plant being allowed to exist in one building for purposes which could very well be fulfilled by one, was most illogical and inefficient, and has resulted in a reopening of the question. This is assisted by the fact that the arc lamp is at last being recognised as the only rational means of public lighting, and its use is therefore being very rapidly extended.

On continuous current supply systems, the problem of arc lighting is not difficult of solution. The ordinary network has its coefficient of service increased by connecting the public lighting to it, but in alternating current supplies the case is different.

The alternating current arc lamp is not so efficient as a generator of light as the continuous current arc. The reasoning of Professor Forbes in his recent Cantor lectures to the contrary is very interesting, but as it is in direct conflict with the results of all experiments hitherto made we are bound to confess, that in the present state of our knowledge, the alternate current arc is not so efficient for public lighting as the continuous current. The examples of public lighting by alternate current arcs, which have been recently carried out in various places, may be excellent in themselves, but comparatively their efficiency is not equal to that of continuous current arcs.

This is so far as we at present know. The investigations being carried out by many authorities on this subject may result in the discovery of a more rational proportion between current strength and size of carbon or other factor which may influence the luminous efficiency, but for the present we will discuss matters as they are. The blue tinge of the alternating arc is an objection which may be got over by colouring during diffusion, or alteration in the constitution of the carbons.

Among the possible solutions are the following:—

(*a.*) Alternate current arcs with a separate transformer for each lamp.

(*b.*) Arcs 3 in series off 100 volt network or separate transformer for 3 arcs.

(*c.*) Any number of arcs in series off an alternate current transformer giving varying voltage and constant current and delivering alternate currents into the lamps.

(*d.*) As in *c*, but with commutator or rectifier in the secondary circuit so that pulsating currents are delivered into the lamps.

But the inefficiency of the alternating current arc will veto the adoption of the solutions *a*, *b*, or *c*, unless the efficiency of one generating plant over two is so great as to justify the consequent loss in utilisation.

The fact that the two first systems have been practically adopted and the third suggested, is evidence of the feeling that an advantage is to be gained by having only one type of generating plant.

All these reasons speak with even greater force in favour of the solution *c*, (*d?*) for in addition to every economy gained by systems using only one type of generating plant, it possesses the great advantage of giving arc lamps having a photometric curve very approximately equal to that of an ordinary continuous current arc.

Having gone thus far into the reasons for the adoption of a rectifier it may be well to describe the apparatus, and discuss the various points arising from its use.

Description of a Rectifier for Arc Lighting.

The rectifier consists of two points:—A constant current transformer and a synchronous motor on which is fixed the rectifier commutator.

A transformer, with switches for regulating the secondary voltage, drives the synchronous motor.

The two primary coils are fixed on to the horizontal limb of the iron circuit. The four secondary coils are movable, and on either side of the fixed primaries.

Counterpoises are fixed to the suspending rods of the movable coils so that the repulsion between the primary and secondary is just balanced when the normal current is given out by the secondary—any increase tends to make the movable coils widen out and a decrease allows them to close together again.

The nett result is that the varying current at constant pressure, which is sent into the primary, is transformed into a constant current at varying voltage in the secondary.

But this current is still alternating; so it is led to the commutator fixed on the end of the motor shaft. The brushes are adjustable by hand and are so set that the current is commuted when it is at zero. The curve of the current is thus changed.

As has already been stated, this shape of current is quite suitable for arc lamps and allows them to derive all the advantage of continuous currents while the uniformity of plant in the generating station is maintained.

The most natural divisions into which a consideration of the uses of the rectifier falls, are:—

1. Efficiency of rectifier, *per se.*, both apparent and real.
2. Influence of rectifier on the total efficiency when used in conjunction with private lighting plant.
3. Effect of rectified currents on arc lamps and other points in the practical use of rectifiers, and miscellaneous notes.

In considering this question the comparative figures are necessarily taken from Blackpool station, where Brush machines, rectifiers, and alternating arcs, on both simple parallel 3-wire and 3-in-series systems are in use. The figures may vary with each particular case but the broad principle is unchanged.

Efficiency of Rectifier.

The apparent efficiency of a rectifier is of almost as much importance as its real efficiency, for if the power factor be low, the apparent current being high prevents the generating plant being used at its highest capacity, for it is the current density in the armature which, almost always, is the measure of a safe load on any machine.

It is therefore highly important that the power factor of a rectifier should be high. This is, unfortunately, opposed to the attainment of a very high percentage of regulation, for it is equally important that with a varying load from, say 10 per cent. to full load, the current should remain sensibly constant, and this result can only be obtained by a certain loss in efficiency.

However, in the more recent types of rectifier, an apparent efficiency of 90 per cent. and a true efficiency of 95 per cent. is obtained with good regulation between $\frac{1}{10}$th load and full load.

The results with the earlier types were not so satisfactory on account of greater attention being paid to regulation than to efficiency, but seeing that on public lighting circuits the load ought never to fall below 50 per cent. of full load, there is no necessity for good regulation below that point except in the case of a blow over on to the secondary commutator, but even in this case the regulation need only be such as to prevent damage to the windings through over heating or fusion of the brushes.

Influence of Rectifier on the Total Efficiency of a Lighting Plant.

For a modern steam alternator an efficiency

$$\frac{\text{E.H.P.} \times 100}{\text{I.H.P.}}$$

of 85 per cent. is unusually high.

And as the efficiency of the rectifier complete is 90 per cent. it follows that the efficiency

$$\frac{\text{Energy in lamps} \times 100}{\text{I.H.P.}}$$

is equal to 95 per cent. of 85 per cent. = 80·75.

This is looking at it in its barest and least favourable light. If we compare the efficiency of an alternate current plant and rectifier with a Brush or Thomson-Houston plant, the comparison is still more favourable.

The following are results of tests of a Brush 55 lighter set at Blackpool under ordinary working conditions.

The engine was a horizontal compound engine by Fowler & Co. Cylinders, 9 and 14 inches by 16 inch stroke. Speed, 150.

The dynamo was a Brush 8 L machine.

Tracings of the indicator cards do not show any abnormal characteristics, excepting the want of balance between the high and low pressure cylinders. This, however, would not affect the efficiency to any great extent.

Table I.

Date.	No. of card.	H.P.		L.P.		Total I.H.P.	Volts.	Amp.	E.H.P.	$\frac{\text{E.H.P.} \times 100}{\text{I.H.P.}}$
		M.E.P.	I.H.P.	M.E.P.	I.H.P.					
July 25	1	53·62	40·560	12·2	22·579	63·199	2,300	9·9	30·522	48·34
—	2	54·75	41·410	12·45	23·042	64·452	2,300	9·9	30·522	47·35
—	3	55·00	41·600	12·58	22·299	64·899	2,300	10·0	30·831	47·507
—	4	55·50	41·979	12·45	23·042	65·021	2,300	9·8	30·214	46·469
—	5	53·57	40·518	12·58	23·299	63·817	2,300	9·8	30·214	47·346
—	6	55·05	41·637	12·77	23·635	65·272	2,360	10·0	30·831	47·235

Mean efficiency 47·37 per cent., as against 80·75 per cent. for rectifier and alternator.

I am quite aware that the results are low. Indeed they have been exceeded at Blackpool where the same plant when new gave slightly better results. The difference, however, was not more than 5 per cent.

The efficiency of some American plants using larger sizes of Brush machines is as high as 75 per cent. But this is exceptional.

But the comparison is by no means ended here. As already indicated, 55 lighter (30 kw.) arc machines are about the largest generally in use in England, and such a dynamo rope driven from an ordinary engine takes up a floor space of about 500 square feet.

This is leaving a space 2 feet wide round the plant for attendance. Such a plant direct driven would take up only 220 square feet, or 16 and 7 square feet per kw. respectively.

A modern 300 kw. steam alternator would occupy 500 square feet, or 1·6 per kw. If space for 300 kw. of rectifiers be included, this will add 200 square feet to the last figure and make the gross space per kw. 2·3 square feet. The importance of this point is most apparent.

The fact that a power equal to 10 55-lighters can be generated by one steam alternator and attended to by one man is another.

So far the arguments have been confined to those in favour of rectifiers *versus* other types of machines for series arc lighting only.

The next point worthy of consideraiion is that, the load of the rectifier being dealt with by the energy lighting plant, its efficiency should really be

$$\frac{\text{Energy in arcs}}{\text{Added energy in engines.}}$$

For example, suppose a station to have a load of 200 kw., and to have 100 kw. in rectifiers added. The true measure of the efficiency should be

not, $\frac{300 \text{ kw.}}{\text{I.H.P.}}$ but $\frac{300 \text{ kw.} - 200 \text{ kw.}}{\text{I.H.P.}_2 - \text{I.H.P.}_1}$

Where I.H.P._1 is the I.H.P. to drive the ordinary load, and I.H.P._2 to drive the combined loads.

Table annexed gives indicator cards taken from 200 kw. plant when driving first, ordinary load, second ordinary load with rectifier added.

Effect of Rectifed Currents on Arc Lamps.

Rectified currents, when sent through circuits having self-induction, produce effects intermediate between those observed with direct and alternating currents.

To observe the extent of this effect the following experiment was carried out with the results tabulated.

A measured current was sent through a choking coil and the voltage at the terminals of the coil noted.

With a current of 9·52 amperes flowing the voltage at the terminals of the impedance coil were :—

For continuous current from a Brush machine ...	5·76 volts.
For alternating currents, 83 v. per second from an E.C.C. alternator	83·0 „
For the above currents rectified	57·5 „

It therefore follows that in arc lamps intended for use with rectified currents main cores should be laminated and the bobbins split. It is not necessary that this be done for the shunt coils. The "pull" on the core is rather less and more sluggish than with a continuous current so that a fresh adjustment requires to be made. The lamps are also perceptibly longer in "striking" than with continuous currents.

The illumination from a rectified arc lamp is not perceptibly different from that of a continuous current arc. For photometric curves of any reliability to be made requires more elaborate apparatus than is generally found in an electric supply works.

Effect of Rectified Current Series Arc Lighting Circuits on Telephones.

There is an undoubted influence on telephone circuits when rectified currents are used in series circuits as generally arranged. The means for the prevention of such interference are peculiar to each case; but, speaking generally, they are such as apply to the prevention of interference of one telephone line upon another—that is, perfect electrical balance on the circuit, and perfect insulation.

Maintenance of Rectifier.

The apparently heavy sparking at the brushes of a rectifier is not so damaging to the commutator as might be imagined; with care the commutator will last quite as long as those of other types of arc lighting machines. Care has to be exercised in the set of the brushes, both on the low tension or motor end, and on the high tension or rectified end.

The influence of the method of driving the alternator on the motor is very perceptible—with one machine the motor current is as steadily low as possible, while with a small machine, lightly loaded, on which the ropes jump, the motor current has to be set fairly high if steady running has to be obtained.

The danger from the use of a rectifier for currents at such high tension, which has been mentioned by one or two people, has not shown itself in practical use with us.

The maintenance of the apparatus has been a matter of much greater ease and economy than of any other arc lighting plant in the station. This is not difficult to understand, as only two coils are movable, and these need not move more than six inches a day. Excellent insulation is obtained, and altogether there is every facility for easy maintenance.

Conclusion.

It is with the hope that a discussion on the various systems of generation for arc lighting may be opened, that this paper has been prepared. It is undoubted that there are more inefficiencies in our present arc lighting systems than in any other branch of electrical engineering; and the most lively satisfaction of the writer will be experienced if a closer investigation into all the details of this most important branch is provoked.

The Electric Wiring Question.—Should any of our readers desire to have in pamphlet form the paper read by Mr. F. Bathurst on "The Electric Wiring Question," along with his reply to the protracted discussion on the subject before the Institution of Electrical Engineers, they can obtain same by applying to the General Electric Company, Limited, of 69, Queen Victoria Street, London, E.C. The paper and the discussion appeared in our columns a month or so ago.

ALTERNATE CURRENT DYNAMO-ELECTRIC MACHINES.*

By J. HOPKINSON, F.R.S., and E. WILSON.†

The paper deals experimentally with the current induced in the coils and in the cores of the magnets of alternate current machines by the varying currents and by the varying positions of the armature. It is shown that such currents exist and that they have the effect of diminishing to a certain extent the electromotive force of the machine when it is working on resistances as a generator without having a corresponding effect upon the phase of the armature current. It is also shown that preventing variations in the coils of the electro-magnet does not, in the machine experimented upon, greatly affect the result, and that the effect of introducing copper plates between the magnets and the armature has not a very great effect upon the electromotive force of the armature, the conclusion being that the conductivity of the iron cores is sufficient to produce the main part of the effect. A method of determining the efficiency of alternate current machines is illustrated and the results of the experiments for this determination are utilised to show that in certain cases of relation of phase of current to phase of electromotive force the effect of the local currents in the iron cores is to increase instead of to diminish the electromotive force of the machine.

I.

In algebraic discussions of the theory of alternate current machines, it has usually been assumed that the electromotive force due to the magnets is a periodic function, the same whether there is a current in the armature or not, and that the effect of the current in the armature can be represented by regarding the armature as having self-induction. It has been pointed out, too, that the coefficient of self-induction will generally vary with the position of the armature in the field. To state exactly the same thing in another way it has been assumed that the electromotive force of the magnets is a periodic function independent of the current in the armature, and that the effect of the armature current on the induction through the armature can be represented as an armature reaction which vanishes at the moment when the current in the armature vanishes.

To state the matter in the form of an equation, let E be the electromotive force of the machine on open circuit, R the resistance of the armature circuit, x the current in the armature, T the periodic time, then it is assumed that

$$\text{R}\, x = \text{E} - (\text{L}\, x)' ;$$

E being independent of x, L being, if you please, a coefficient of self-induction constant or variable, or, if you prefer it, L x representing the change in the induction through the armature due to the current in the armature, vanishing with x.

It is easy to see that this statement is true in some cases. For example, it is very nearly true in the older machines with permanent magnets. Or imagine a machine without iron in the magnets or armature, consisting merely of two circuits—one the magnet circuit, the other the armature circuit—movable in relation to each other. If the current in the magnet circuit is kept precisely constant, either by inserting a great self-induction in its circuit external to the machine, or by inserting such a resistance and using so high an electromotive force that any disturbing electromotive forces are inappreciable compared with it, the preceding statement is strictly accurate. But if the magnet current is not forced to be constant the problem is more complicated.

Stating the matter in the language of self and mutual induction, let x and y be the currents in armature and magnet circuits, R and r their resistances, L and N their self-induction, M sin $2\pi t/\text{T}$ their mutual induction, F the constant electromotive force applied to the magnet, the equations for the system are :—

$$\left.\begin{aligned} \text{R}\, x &= -\text{M}\,(y \sin 2\pi t/\text{T})' - \text{L}\, x \\ r\, y &= \text{F} - \text{M}\,(x \sin 2\pi t/\text{T})' - \text{N}\, y \end{aligned}\right\}$$

These equations can be solved by approximations if the variations in the value of y are small.

First,

$$y = \frac{\text{F}}{r}; \quad x = -\frac{\text{M F}}{r}\,\frac{2\pi}{\text{T}}\,\frac{\text{R}\cos 2\pi t/\text{T} + 2\pi\,\text{L}/\text{T}\sin 2\pi t/\text{T}}{\text{R}^2 + (2\pi\,\text{L}/\text{T})^2}.$$

Second, substituting this value of x, we obtain

$$r\, y = \text{F} + \frac{\text{M}^2\,\text{F}}{r}\cdot\frac{2\pi/\text{T}}{\text{R}^2 + (2\pi\,\text{L}/\text{T})^2}\left\{\frac{\text{R}}{2}\sin\frac{4\pi t}{\text{T}} + \frac{\pi\,\text{L}}{\text{T}}\left(1 - \cos\frac{4\pi t}{\text{T}}\right)\right\} - \text{N}\, y.$$

This gives periodic terms in y, the period being one-half the period of the mutual induction.

Introducing these terms into the first equation, we see that the term in $2\pi t/\text{T}$ in the electromotive force of the machine is modified, and that terms in $6\pi t/\text{T}$ are introduced. The former may have real practical importance, and it is one of the objects of the present paper to ascertain how far it exists and is of importance in actual machines.

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* Read before the Royal Society, May 2nd, 1895.

† The large majority of the experiments herein described were made in the summer of 1893 and a considerable part of the paper was then written. We have to thank Mr. F. Lydall, one of the student demonstrators at King's College at that time, for much assistance.

Returning to machines as ordinarily constructed, in these the current in the magnet coils is not compelled to be constant, and any rapid variation of the induction in the magnet cores will induce currents in those cores. The variations in the current in the magnet coils and the currents in the cores both tend to annul the variations in the induction in the core arising from the current in the armature, but they will not tend to alter the *average* effect of the currents in the armature on the induction through the magnets. That there will be such an average effect is not difficult to see. Suppose the armature coils to be fixed in line with the magnets of the machine, any current in the armature will have its full effect in increasing or diminishing the field through the magnets. Suppose the armature coils to be fixed midway between the magnets, any current in the armature will then have practically little or no effect in increasing or diminishing the field through the magnets. If the armature be connected through resistance, inductive or non-inductive, and the machine run in the ordinary way, the current in the armature will lag in phase behind the electromotive force, E. The result is that when the armature is opposite to the magnets there is a current in the armature tending to demagnetise the magnets, and adding together the effects of the armature in all positions, there is an average effect tending to demagnetise the magnets. If the machine had a constant current round the magnets and divided iron in the magnets, this average effect, as well as its variations, would be fully accounted for by the term ($L\ x$), call it self-induction or call it armature reaction, as you please. But inasmuch as the variations are in part annulled by the variations of current in the magnet winding and the local currents in the magnet cores, we have a part of the diminution of the electromotive force, E, of the machine unaccompanied by retardation of phase of the current in the armature.

Before giving any experimental results, it will be well to describe the machines used and the general method of experiment adopted.

The two dynamos experimented upon were constructed by Messrs. Siemens Bros., and are of the same pattern and size but are of an old type. They are mounted upon a common base-plate, their pulleys being provided with flanges and bolts, so that any desired phase difference can be given to the armatures, for the accurate setting of which a graduated circle is provided, or so that the armatures can be run independently of each other. The pulleys have each a diameter of 12 inches, and are suited for a 6-inch belt—the shaft is prolonged for the purpose of carrying a revolving contact-maker and a small pulley for driving a Buss tachometer.

Each dynamo has a series of 24 electro-magnets (see fig. 1), there being 12 on either side of the armature. The core of each magnet (A) is of wrought iron $2\frac{1}{8}$ inches diameter, and $6\frac{1}{2}$ inches long; and is wound with 5 layers, 35 convolutions per layer, of copper wire 3·5 millims. diameter. The electro-magnets are bolted to circular cast-iron frames (B), which serve also for supporting the bearings of the armature shaft. The centres of the 12 electro-magnets on each frame are equally spaced out on a circle of $8\frac{7}{8}$ inches radius concentric with the axle of the machine. Each cast-iron frame has a cross-sectional area of 4·8 square inches. The opposing pole pieces of the electro-magnets have an air space of $1\frac{1}{8}$ inch between them, through which the armature coils rotate. The 24 electro-magnet windings are coupled in series, and have a total resistance of 1·8 ohms, the normal exciting current being about 22 amperes.

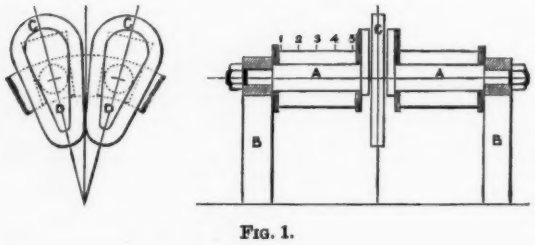

Fig. 1.

The armature of each dynamo consists of 12 coils or bobbins (C) with wooden cores (D) $\frac{7}{8}$-inch thick. Each core is 7 inches long (radially), with rounded ends—the outer being struck to a circle $3\frac{1}{8}$ inches and the inner $1\frac{1}{8}$ inches diameter. The ends of the respective coils are brought to a screw-plug commutator board fixed to the shaft, by means of which a series of combinations can be made. Each coil consists of 10 layers, 8 convolutions per layer, 2·2 millims. copper wire, having a resistance (cold) of ·187 ohm, and at a speed of 1,000 revolutions per minute, with normal excitation and fully loaded, is intended to give 50 volts at its extremities. The full load current for each coil is 16·6 amperes, so that at 1,000 revolutions per minnte, or a frequency of 100 complete periods per second, the machine should give with its 12 armature coils in parallel, an output of 200 amperes 50 volts. The two terminal rings of the screw-plug commutator are connected by conductors to two gun-metal collector rings, insulated from one another and from the shaft by means of ebonite. Each collector ring is provided with two 1-inch copper wire brushes, carried by adjustable bar-holders fixed to the terminal blocks of the dynamo.

The potential difference between any two points at any epoch is determined by means of a Kelvin quadrant electrometer and a revolving contact-maker fixed to the shaft of the dynamo. The contact maker consists of a disc of gun-metal which carries two rings, one of gun-metal insulated from the disc, the other of ebonite. Into the latter is inserted a strip of metal $\frac{5}{16}$-inch wide, which is in permanent contact with the gun-metal ring. Two insulated brushes are attached to a movable brush-holder, so that one presses on each ring. The circuit between the two brushes is completed once in each revolution, and the position of the contact can be read off by a pointer attached to the holder on a circle $13\frac{1}{4}$ inches diameter, divided into 360°. The two points between which it is desired to measure the potential difference are connected through the contact maker to a condenser and the quadrant electrometer, as shown in fig. 2, in which A and B are the points, C the revolving contact maker, D the reversing switch of the

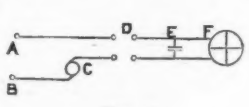

Fig. 2.

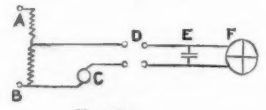

Fig. 3.

electrometer, E the condenser, and F the quadrant electrometer. By plotting as ordinates the volts measured at any epoch, and as abscissæ the position of the contact maker as representing time, the curve of potential is obtained. The electrometer is standardised by means of a Clark cell, so that the deflections on the scale can be reduced to volts; when the potential difference between A and B was too great for the electrometer, it was reduced in any desired ratio by two considerable non-inductive resistances introduced between A and B, as shown in fig. 3.

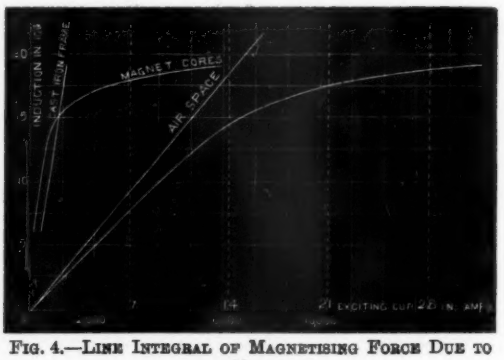

Fig. 4.—Line Integral of Magnetising Force Due to two Magnets.

The characteristic curve of the alternator is given in fig. 4, and shows the relation between the total induction I, between one pole piece and the opposing one, in terms of the line integral of magnetising force due to the two windings in series on the two respective magnet cores; the scale of amperes in the magnet winding is also given horizontally.

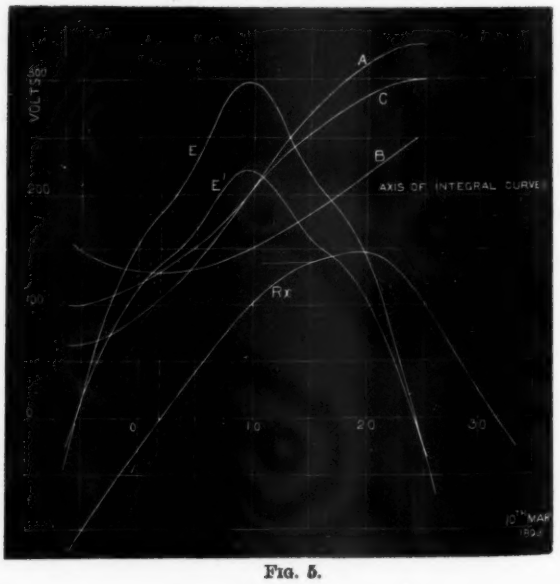

Fig. 5.

In fig. 5 the speed of the alternator experimented upon was 923 revolutions per minute, or a frequency of 92·3 complete periods per second. For the purpose of obtaining a marked effect from the current in the armature a large current was taken out of the armature, and the current in the magnet winding was only 8 amperes. A Kelvin multicellular voltmeter placed across the terminals of the machine read 190 volts on open circuit, and 81 volts when loaded, and a Kelvin ampere balance in the external non-inductive circuit read 40 amperes. The armature bobbins were coupled 6 in series 2 parallel

between the brushes, the total resistance of the circuit (R) was 2·52 ohms, the armature resistance alone being ·55 ohm.

Curve E is the electromotive force curve of the machine when there is no current in the armature. R x is the curve of electromotive force deduced from the potential difference taken between the terminals of the alternator when supplying current through non-inductive resistances. The curves E and R x have been integrated, the corresponding integral curves being A and B respectively.

That the ordinary theory does not fully account for the facts is easily shown. We have $\mathrm{R}\,x = \mathrm{E} - (\mathrm{L}\,\dot{x})$. Integrate both sides from any fixed epoch 0 to any time t and we have

$$\int_0^t \mathrm{R}\,x\,dt = \int_0^t \mathrm{E}\,dt - \mathrm{L}\,(x_t - x_0).$$

Each term of this equation consists of a constant part and of a periodic part. The constant parts must be equal and also the periodic parts. We have to deal only with the periodic parts. The curves A and B, fig. 5, represent the periodic parts of each of the first two terms; the difference of ordinates of these curves should at all times be equal to L x. In particular, and this is the only point of moment, as we do not know how L may vary, when L x vanishes $\int \mathrm{R}\,x\,dt = \int \mathrm{E}\,dt$.

If the effect of the current in the armature on the induction through the armature could be represented by a term which vanishes with the current in the armature, it is obvious that the curves A and B would cross at the epoch when $x = 0$. They do not. The difference of inductions as given by these curves at this epoch is 25 per cent. of the induction which would *then* traverse the armature coil if the machine were running on open circuit, that is to say, 25 per cent. of the ordinate at this epoch given by the A curve. If it is assumed that the *average* effect of the armature current upon the induction in the magnets is such as to lower this induction by 25 per cent., the ordinates of the E curve would be decreased in like proportion, giving the curve E′ of which C is the integral. The difference at any epoch between the curve C and the R x curve is to be fully accounted for by the term (L $\dot{x}$).

We may put it in this way. In this machine the armature current at the times when it has a value affects the field at the instant when the armature current is zero. The effect is produced by variations induced in the current in the field magnet-winding and in the solid iron of the magnets by the varying current in and the varying position of the armature. That these induced currents must exist is obvious, and it is easy enough to measure them in the copper coils. They have the effect of causing the armature reaction to produce an average effect upon the magnetism of the fields by partially annulling its periodic effect. If the current in the armature did not lag behind the electromotive force of the magnets E, there would be little or no

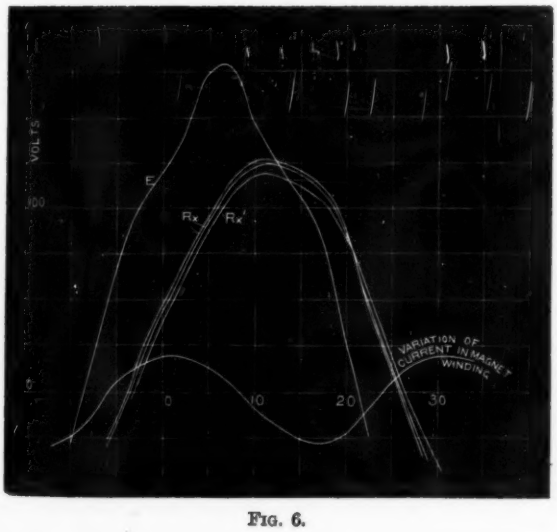

Fig. 6.

diminution of the average magnetism of the magnets. We may correctly say that this diminution of the magnetism of the magnets, is due to the self-induction of the armature causing a lag of current. The effect arises from the self-induction of the armature modified by currents induced in the magnets.

The effect on the magnets of any current in the armature is greatest when the armature bobbins are opposite the pole-faces, it is *nil* or small when half-way between the pole-faces. We may therefore represent its effect at any instant approximately as proportional to the expression

$$\frac{2\pi\,\mathrm{L}/\mathrm{T}\,\sin 2\pi t/\mathrm{T} + \mathrm{R}\cos 2\pi t/\mathrm{T}}{(2\pi\,\mathrm{L}/\mathrm{T})^2 + \mathrm{R}^2}\,\sin 2\pi t/\mathrm{T}$$

or

$$\frac{\pi\,\mathrm{L}/\mathrm{T}}{(2\pi\,\mathrm{L}/\mathrm{T})^2 + \mathrm{R}^2} - \frac{\pi\,\mathrm{L}/\mathrm{T}\cos 4\pi t/\mathrm{T} - \mathrm{R}\sin 4\pi t/\mathrm{T}}{(2\pi\,\mathrm{L}/\mathrm{T})^2 + \mathrm{R}^2}.$$

The constant term causes the fall in average magnetism, the periodic term causes currents in the magnets, and its effect on the magnetism is partly annulled thereby. The effect will vary as the square of the current if this is small. The effect of self-induction in diminishing the apparent electromotive force of the machine varies as the square of the current, so that we may expect the two effects, that due to the reaction of the armature on itself and that brought about by the armature inducing currents in the magnets, to vary together.

The lag of phase is less than we should expect from the diminution of electromotive force, or the electromotive force suffers greater diminution than we should expect from the angle of lag of phase.

We have tried a number of experiments for the purpose of tracing the variations of current in the magnets, and also with the intention of increasing or diminishing the effect we have observed. It is easy enough to trace the variations in the current round the magnets by

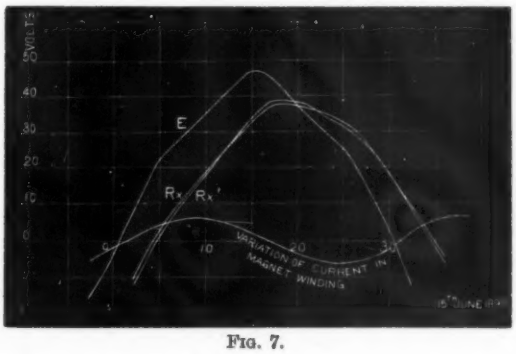

Fig. 7.

measuring at points during the period the potential difference between the ends of a non-inductive resistance in series with the magnets. These variations are shown in figs. 6 and 7, in which the armature bobbins were coupled, 4 series, 3 parallel, and 12 series, respectively. We see, as we should expect, that the variations have a periodic time one-half the periodic time of the machine. But the current round the magnet could be made constant by exciting the two machines with the same current, loading each to the same degree, and placing their armatures one-fourth part of a period apart in phase.

(To be continued.)

MAGNETIC PROPERTIES OF IRON AND STEEL.

At the ordinary meeting of the Institution of Civil Engineers on Tuesday, May 19th, Sir Benjamin Baker, K.C.M.G., the President, in the chair, two communications dealing with the magnetic properties of iron and steel were considered.

The first paper was entitled, "The Magnetic Testing of Iron and Steel," by Prof. J. A. Ewing, F.R.S., M.Inst.C.E. The author referred to the practical importance which now attached to the magnetic testing of iron and steel in relation to the manufacture of dynamos and transformers. From being a mere laboratory experiment, interesting only to students of physics, it had passed into the rank of an engineering operation. Iron makers now supplied material greatly superior, from the magnetic point of view, to that which could be obtained even two or three years ago. In dynamo construction, the introduction of permeable steel castings for the field magnets had given greater latitude as to form without loss of efficiency, the best steel castings being indeed somewhat better magnetically than most forged iron. In stampings of sheet metal for transformers, the main consideration was absence of hysteresis, and so great had been the advance in this respect, that iron was now readily obtainable with only half the amount of hysteresis which was considered possible a few years ago. This had brought about a notable increase in the efficiency of alternate current distribution, by reducing the large element of loss which occurred through the hysteresis of transformed cores during the hours of light load, as well as of heavy load. The author recalled the conventions, according to which the magnetic quality of iron was expressed. The most usual test was one to determine the relation of the magnetic induction to the magnetising force, the ratio of B to H being the permeability. To enable H to be determined with accuracy, the specimen was arranged as a closed ring, or as an ellipsoid, or as a bar or bars rendered practically endless by the use of a yoke. Ballistic methods of testing were described, and it was shown how in the use of a yoke the proper correction might be experimentally found, to deduce the true magnetising force by allowing for the magnetic resistance of the yoke itself. For this purpose, the author used a pair of bars joined by two short yokes at their ends, the yokes being shifted so as to include either the whole length or half the length of the bars in the magnetic circuit. Reference was made to various forms of apparatus designed to measure the magnetic induction by observing the force required to separate surfaces in the magnetised piece, and a form used by the author was described in which a yoke piece was simultaneously drawn away by polar extensions at both ends of the bar. A novel apparatus was shown in detail for measuring permeability by comparing the magnetising force required to produce a given induction with the force required to produce equal induction in a standard bar. This apparatus, which the author terms a magnetic bridge* from its analogy to the Wheatstone bridge for the measurement of resistance,

* See Electrical Review, May 15th, page 618.

reduced the operation of testing to a comparison between the specimen and a bar, the magnetic quality of which had been determined once for all by the instrument maker. The two bars were connected by end yokes, and by varying the number of turns in the magnetising coil on one of them, the yokes were brought to the same magnetic potential. The relative number of turns on the two thus gave the relative magnetising forces required to produce the same induction in both. A simple form of magnetic detector showed when the two yokes were brought to the same potential. The manipulation consisted in varying the number of turns acting on one bar by means of dial switches, while the magnetising current was from time to time reversed. This permeability tester was intended for workshop use, and might take its place alongside of the author's hysteresis tester, which was also described. The methods of directly measuring hysteresis were briefly referred to.

A number of representative examples were given of permeability tests of forged wrought-iron, forged steel, and cast steel for dynamo magnets; also of hysteresis tests of transformer plate rolled from Swedish wrought-iron and from ingot metal. The results were shown by means of numerical tables and also in curves.

The second paper, on "Magnetic Data of Iron and Steel," was by Mr. H. F. Parshall, A.M.I.C.E. Magnetic tests of iron and steel might be conducted to determine such properties as permeability, maximum magnetisation, residual magnetism, and permanent magnetism, and the relation they bore to tempering, annealing, internal stresses, composition, and processes of manufacture. The loss of energy through hysteresis might be determined either magnetically by determining the area of the loop formed by plotting the flux densities as ordinates, and magnetic force as abscissæ, or mechanically by suitable power-measuring apparatus. A study of the magnetic results and of the chemical analysis showed a more or less intimate relationship according to the degree with which the modifying physical conditions might be controlled. In general, a greater degree of purity was an indication of high permeability, but as the different qualities of iron and steel merged into each other by insensible degrees, owing to variations in the processes of manufacture, chemical analysis might be taken only as an approximate indication of the magnetic properties. Carbon was the most important element entering into the composition of commercial iron, and, within the limits that chemical analysis might serve as an indication of the physical structure, the permeability was inversely as the amount of carbon present. The limitation as to the state of physical structure was greatly affected by the state of the carbon, that was, whether free or combined; in cast-iron as well as in steel, the effect of graphite was second to that of the carbide, commonly known as fixed or combined carbon.

Beyond a certain degree of purity, as in wrought-iron and carbon steels, the treatment as to annealing and tempering became of first importance. The magnetic properties of some of the alloys of iron, nickel, or manganese, were such as to show that the physical structure was the ultimate determining factor. The hysteresis loss was in general inversely as the degree of purity, but in comparatively pure irons it was determined principally by its treatment as to annealing, heating, and mechanical straining.

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents*, 322, *High Holborn, London, W.C., to whom all inquiries should be addressed.*]

NEW PATENTS.—1896.

9,959. "Improvements in electrical arc lamps." W. H. Lauder. Dated May 11th.

9,960. "Improvements in electric bell communication." F. Helman and J. Carroll. Dated May 11th.

9,964. "Improved electric cables." G. H. Nisbett. Dated May 11th.

9,974. "Improvements in and connected with electrical switches." M. Binswanger and F. G. Bell. Dated May 11th.

9,975. "Improvements in and relating to conduits for electrical conductors." F. Bathurst. Dated May 11th.

9,976. "Improvements in hand telephones and in compound switches therefor." M. Binswanger and F. G. Bell. Dated May 11th.

9,992. "Improvements relating to electric traction." H. J. Allen. Dated May 11th.

10,015. "Improvements in writing telegraphs." R. J. Crowley and A. B. Hutchings. Dated May 11th.

10,017. "Improvements in electric arc lamps." W. J. Davy. Dated May 11th.

10,027. "A combined magnet washing, sifting, and metal extracting machine." J. Johnson. Dated May 11th.

10,047. "System of and means for electrical transportation." P. S. Stern. Dated May 12th.

10,069. "A new or improved method of and apparatus for electrically controlling or adjusting the position of rudders, guns, signals, and other devices." M. Pfatischer. Dated May 12th.

10,095. "Improvements in electric batteries." P. Schmidt. Dated May 12th.

10,096. "Improvements in arc electric lamps." A. O. Mackin. Dated May 12th.

10,106. "Improvements in step-by-step printing telegraphs." W. S. Steljes. Dated May 12th.

10,119. "Electrical thief alarm for vehicles." J. Pearson and W. Gooding. Dated May 12th.

10,124. "Improvements in systems of distribution of alternating electric currents." A. Lemgauer. (C. P. Steinmetz, United States.) Dated May 12th.

10,127. "Improvements in electric tram trolleys." H. H. Leigh. (H. R. Keithley, United States.) Dated May 12th.

10,134. "An improved system of and apparatus for the collection of electricity from overhead conductors and in conduits connected therewith." W. J. Brewer. Dated May 12th.

10,171. "Improvements in thermostatic circuit closers for electric fire and heat alarms." F. Dresser. Dated May 13th.

10,189. "Improvements in carbon brush holders for electromotors and dynamos." F. H. Royce and E. A. Claremont. Dated May 13th.

10,205. "An improved tumbler or lever action switch for electric power or light." F. W. Heaton, H. Smith, and A. Lindley. Dated May 13th.

10,267. "Improvements in electrodes for galvanic batteries." C. Hoepffner. Dated May 13th.

10,272. "Improvements in dynamo-electric machines." H. T. Harrison. Dated May 13th.

10,284. "A new and improved reflector in connection with glass bulbs or glow lamps for electrical lighting." G. W. Pridmore, T. J. Sturgeon, and E. Yorke. Dated May 14th.

10,349. "A process of preparing metals for galvanic, electrolytic, and for other purposes." A. M. Clark. Dated May 14th.

10,358. "An improved system for registering or storing electric currents, and for reconstituting and delivering the currents so stored." H. Carbonnelle. Dated May 14th.

10,414. "Improvements in electric hoists." W. H. Scott. Dated May 15th.

10,415. "Dynamo-electrical collecting apparatus." W. Sillery. Dated May 15th.

10,429. "Improvements in holders for electric glow lamps." T. R. D. Kenny. Dated May 15th.

10,455. "Improvements in electric motors." R. Norman. Dated May 15th.

10,456. "Improvements in electric motors and their arrangement." R. Norman. Dated May 15th.

10,472. "An improvement in active material for secondary voltaic batteries." G. A. Grindle. Dated May 15th.

10,497. "Improvements in or relating to electric traction." J. Perry and T. Tomlinson. Dated May 15th.

10,608. "An improvement in tumbler electric switches." The Edison and Swan United Electric Light Co., Ltd., and C. F. Proctor. Dated May 16th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Copies of any of these Specifications may be obtained of* Messrs. W. P. Thompson & Co., 322, High Holborn, W.C., *price, post free*, 8½*d.* (*in stamps.*)]

1895.

8,564. "Improvements in electric alarms." A. Ducreux. Dated April 30th, 1895. Relates to an electric alarm whereby any number of persons may be called by means of one instrument at the same or different times. The apparatus comprises a clock having contacts in connection with the hour hand terminating in binding screws at the face of the dial, the dial has also binding screws connected with bells in the various rooms, and means are provided for bridging the two sets of binding screws in any desired manner. 1 claim.

20,626. "Improvements in electric arc lamps specially applicable for lantern purposes." F. W. Branson. Dated November 1st, 1895. Relates to the class of lamps in which the carbons are carried upon the ends of two pivoted levers and describes arrangements for striking and regulating the length of the arc by hand. 8 claims.

1896.

474. "Improved turning plate for electrically or mechanically propelled vehicles." W. C. Bersey. Dated January 7th, 1896. The plate is arranged to revolve on ball bearings. 1 claim.

780. "A new or improved method of manufacturing electrodes for secondary electric batteries." H. Leitner. Dated January 11th, 1896. The method consists in powdering and mixing lead oxide with carbon, converting same into a stiff paste with glycerine or the like; forming the paste into flat or curved plates; reducing the same electro-chemically to porous lead, and subjecting the porous plates to pressure. 1 claim.

3,032. "New or improved self-acting electrical signalling apparatus for preventing collisions on railways." H. O. Krapp. Dated February 10th, 1896. The apparatus comprises an electric battery on the locomotive, an indicator on the same, conductors connecting these with the main conductor, and conducting devices on the vehicle which forms the obstacle for the purpose of connecting together electrically the two parts of the main conductor at the point where the obstacle occurs. 2 claims.